Prime Minister Formalization of
Micro Food Processing Enterprises Scheme
(PM-FME SCHEME)

TRAINING FOR MASTER TRAINERS

HANDBOOK OF SPICES AND PLANTATION CROPS PROCESSING

Organized by

ICAR-Central Plantation Crops Research Institute
Kasaragod, Kerala, India

In Collaboration with

Indian Institute of Food Processing Technology,
Thanjavur, Tamil Nadu

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MoFPI sponsored Master Trainers Training on “Spices and Plantation Crops Processing”

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CHAPTER 1

INTRODUCTION

1.1. Overview of PM Formalisation of Micro Food Processing Enterprises Scheme (PM FME Scheme)

The unorganized food processing sector in the country comprises nearly 25 lakh food processing enterprises which are unregistered and informal. With only 7% of investment in plant & machinery and 3% of outstanding credit, the unorganized enterprisescontributeto74% of employment (a third of which are women), 12%of output and 27% of the value addition in the food processing sector. Nearly 66% of these units are located in rural areas and about 80% of them are family-based enterprises1. Most of these units fall under category of micro manufacturing units in terms of their investment in plant & machinery and turnover.

The unorganized food processing industry in India faces challenges that limit its development and weakens performance. These challenges include: (a) lack of productivity and innovation due to limited skills and access to modern technology and machinery for production and packaging; (b) deficient quality and food safety control systems, including lack of basic awareness on good hygienic and manufacturing practices;(c) lack of branding & marketing skills and inability to integrate with the supply chains, etc.;(d) capital deficiency and low bank credit.

Unorganized micro food processing units, need intensive hand holding support for skilltraining,entrepreneurship,technology,creditandmarketing,acrossthevalue chain, necessitating active participation of the state government for better outreach. In the last decade, Central and State Governments have made intensive efforts to organize farmers in Food Processing Organisations (FPOs) and women's Self Help Groups (SHGs). SHGs have achieved considerable progress in thrift and their repayment record with 97% NPA level is among the best. Governments have made efforts to enable SHGs to undertake various manufacturing and service sector activities including food processing. However, there are few Government schemes to support FPOs and SHGs to make investment and upscale their operations.

This scheme is a centrally sponsored scheme that is designed to address the challenges faced by

the micro enterprises and to tap the potential of groups and cooperatives in supporting the up gradation and formalization of these enterprises.

Aims

The scheme aims to:

- Enhance the competitiveness of existing individual micro-enterprises in the unorganized segment of the food processing industry and promote formalization of the sector; and
- Support Farmer Producer Organizations (FPOs), Self Help Groups (SHGs) and Producers Cooperatives along their entire value chain.

Objectives

The objectives of scheme are to build capability of microenterprises to enable:

i) Increased access to credit by existing micro food processing entrepreneurs, FPOs, Self Help Groups and Co-operatives;

ii) Integration with organized supply chain by strengthening branding & marketing;

iii) Support for transition of existing 2,00,000 enterprises into formal framework;

iv) Increased access to common services like common processing facility, laboratories, storage, packaging, marketing and incubation services;

v) Strengthening of institutions, research and training in the food processing sector; and

vi) Increased access for the enterprises, to professional and technical support.

Outlay

The scheme envisages an outlay of Rs. 10,000 crores over a period of five years from 2020-21 to 2024-25. The expenditure under the scheme would to be shared in 60:40 ratio between Central and State Governments, in 90:10 ratio with North Eastern and Himalayan States, 60:40 ratio with UTs with legislature and 100% by the Center for other UTs.

Coverage

Under the scheme, 2, 00,000 micro food processing units will be directly assisted with credit linked subsidy. Adequate supportive common infrastructure and institutional architecture will be supported to accelerate growth of the sector.

One District One Product

The scheme adopts One District One Product (ODOP) approach to reap the benefit of scale in terms of procurement of inputs, availing common services and marketing of products. ODOP for the scheme will provide the framework for value chain development and alignment of support infrastructure. There may be more than one cluster of ODOP product in one district. There may be cluster of ODOP product consisting of more than one adjacent district in a State.

The States would identify the food product for a district, keeping in perspective the focus of the scheme on perishables. A baseline study would be carried out by the State Government. The ODOP product could be a perishable agri produce, cereal based product or a food product widely produced in a district and their allied sectors. Illustrative list of such products includes mango, potato, litchi, tomato, tapioca, kinnu, bhujia, petha, papad, pickle, millet based products, fisheries, poultry, meat as well as animal feed among others. In addition, certain other traditional and innovative products including waste to wealth products could be supported under the Scheme. For example, honey, minor forest products in tribal areas, traditional Indian herbal edible items like turmeric, amla, haldi, etc. Support for agricultural produce would be for their processing along with efforts to reduce wastage, proper assaying and storage and marketing.

With respect to support to existing individual micro units for capital investment, preference would be given to those producing ODOP products. However, existing units producing other products would also be supported. In case of capital investment by groups, predominately those involved in ODOP products would be supported.

Support to groups processing other products in such districts would only be for those already processing those products and with adequate technical, financial and entrepreneurial strength.

New units, whether for individuals or groups would only be supported for ODOP products. Support for common infrastructure and marketing & branding would only be for ODOP products. In case of support for marketing & branding at State or regional level, same products of districts not having that product as ODOP could also be included.

Department of Commerce is focusing on agriculture crops on a cluster approach for support for exports under the Agriculture Export Policy and Ministry of Agriculture is also focusing on cluster approach for development of specific agri- produce in districts having comparative advantage. A number of states have adopted similar cluster based development. The ODOP approach of the Scheme would lead to ease in providing common facilities and other support services.

Support to Food Processing Units

Support to food processing units would be provided for the following:

(i) Credit linked grant at 35% of the project cost with maximum grant up to Rs 10.0 lakh to existing unorganized food processing units for up gradation;

(ii) Credit linked grant at 35% of the project cost to SHGs/FPOs/cooperatives for capital expenditure with maximum limit as prescribed;

(iii) Seed capital @ Rs. 40,000/- per member to those engaged in food processing as a working capital;

(iv) Credit linked grant at 35% of the project cost for common infrastructure with maximum limit as prescribed;

(v) Support for marketing & branding up to 50% of the expenditure with maximum limit as prescribed.

Upgradation of Processing Units

Individual Category: Individual micro food processing units would be extended credit-linked capital subsidy @35% of the eligible project cost for expansion/ technology upgradation with a maximum ceiling of Rs.10 lakh per unit. The beneficiary contribution should be minimum10% and the balance should be loan from a Bank.

Eligibility criteria:

(i) Individual / Partnership Firm with ownership right of the enterprise;

(ii) Existing micro food processing units in the survey or verified by the Resource Person;

(iii) The applicant should be above 18 years of age and should possess at least VIII standard pass educational qualification;

(iv) Only one person from one family is eligible for obtaining financial assistance. The "family" for this purpose would include self, spouse and children.

Procedure for applying for upgradation:

Applications would be invited at the district level on an ongoing basis for units interested in availing the benefi ts under the Scheme. Existing food processing units desiring to seek assistance under the scheme should apply on the FME portal. Loan proposals would be recommended to the Banks after scrutiny. States would decide the appropriate level for short listing of the applications to be recommended to the Banks.

Procedure with Banks for Grant:

At the national level, a Nodal bank would be appointed for disbursement of subsidy to the banks and liaison with the banks extending loan to the beneficiaries. The bank sanctioning the loan would open a mirror account in the name of the beneficiary. Grant by the Central and State Government in 60:40 ratio would be deposited in this account of beneficiary in the lending bank branch by the State and Central Government. If after a period of three years from the disbursement of last tranche of the loan, the beneficiary account is still standard and the unit is operational, this amount would be adjusted in the bank account of beneficiary. Release of grant for groups and common infrastructure would also be done in their bank account following the same principle.

Group Category: The Scheme would provide support in clusters to groups such as FPOs/ SHGs/ producer cooperatives along their entire value chain. SHGs / FPOs / Producer Cooperatives would be provided the following support:-

(i) Grant @35% with credit linkage for capital investment with maximum limit as prescribed;

(ii) Training support;

(iii) Support for marketing and branding for products under ODOP for developing common brand.

Eligibility Criteria:

(i) It should be engaged in processing of ODOP produce for at least three years;

(ii) In case of FPOs / cooperatives, they should have minimum turnover of Rs.1 crore and the cost of the project proposed should not be larger than the present turnover;

(iii) The SHG / cooperative / FPO should have sufficient internal resources to meet 10% of the project cost and margin money for working capital.

Seed Capital to SHG:

The scheme envisages provision of Seed Capital @ Rs. 40,000/- per member of SHG engaged in food processing for working capital and purchase of small tools. Seed capital as grant would be provided at the federation level of SHGs which, in turn, will be extended to members as loan through SHG.

Eligibility criteria:

For Seed Capital, only SHG members who are presently engaged in food processing would be eligible. The SHG member has to commit to utilize this amount for working capital as well as purchase of small tools and give a commitment in this regard to the SHG and SHG federation.

Creation of Common Infrastructure

FPOs/ SHGs/ Producer Cooperatives /State agencies or private enterprises would be supported for creation of common infrastructure including for common processing facility, incubation center, laboratory, warehouse, cold storage, etc. Eligibility of a project under this category would be decided based on benefit to farmers and industry at large, viability gap, absence of private investment, criticality to value chain, etc. Credit linked grant would be available @ 35% with maximum limit as prescribed.

Branding and Marketing Support

Marketing and branding support will be provided to FPOs/SHGs/Cooperatives or an SPV of micro food processing enterprises under the scheme following the cluster approach for developing common packaging & branding with provision for quality control, standardization and adhering to food safety parameters for consumer retail sale.

Support for Marketing and Branding requires a minimum volume which can be generated through active involvement of FPO/ SHG/ Cooperatives to bring large number of producers together. These organizations would be supported based on DPR prepared by them indicating essential details of the project. Support up to Rs.5 lakh would be available from State Nodal Agency for preparing DPR for proposals for branding & marketing.

Support for branding and marketing would be limited to 50% of the total expenditure with maximum limit as prescribed. Proposal from states or national level institutions or organizations or partner institutions for branding & marketing will be supported for vertical products at the national level. No support would be provided for opening retail outlets under the scheme.

Procedure for Applying for Support:

In case of SHGs/FPOs/cooperatives or SPV interested in applying for support for branding and marketing under the Scheme, DPR should be prepared and submitted to State Nodal Agency (SNA). SNA would appraise the proposal and with recommendation from the State Level Approval Committee (SLAC) seek approval from MOFPI. Thereafter, the proposal would be recommended to a Bank for sanction of loan. Same procedure should be followed for applying for support for creation of common infrastructure as well.

Capacity Building & Research

Training is a critical component in technical upgradation and formalization of micro food processing enterprises. All individuals & institutions members receiving grant would undergo training for upgradation of their skills. In addition, training support would also be provided to other existing individual units and groups producing ODOP product in the district, even if they are not being supported through credit linked grant. Training support would also be provided for units that are part of support for Marketing & Branding or have potential to join such network.

National Institute for Food Technology Entrepreneurship and Management (NIFTEM) and Indian Institute of Food Processing Technology (IIFPT), two national level food processing technology institutions under MOFPI are given responsibility to spearhead capacity building and research. At the State level, they would partner with a State Level Technology Institution in food processing technology selected by the State Government for conducting capacity building and training.

Training to individual and group beneficiaries will focus on entrepreneurship development, essential functions of enterprise operations, book keeping, registration, FSSAI standards, Udyog Aadhar, GST Registration, general hygiene, packaging, marketing etc. Specific training designed on the model of ODOP and the vertical focus products will be undertaken nearer to the work place of the entrepreneurs. Existing infrastructure of Rural Self Employment Training Institutes (RSETI) and other institutions at the district level will be utilized for imparting training.

Partner Institutions

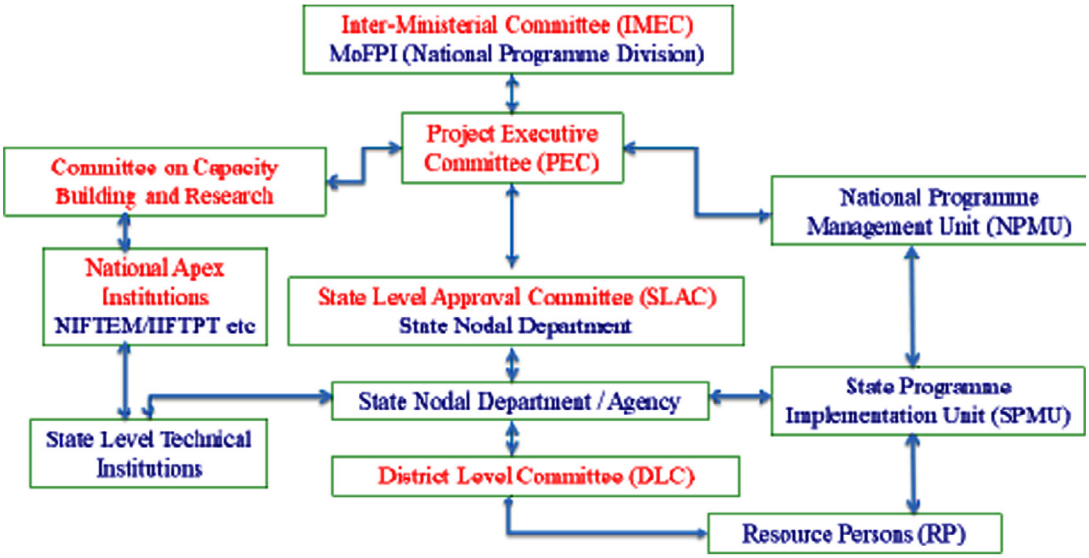
The scheme lays special focus on SCs/STs, women and aspirational districts and FPOs, SHGs and producer cooperatives. TRIFED, National SC Development Finance Corporation, NCDC, Small Farmer Agri-Business Consortium (SFAC) and National Rural Livelihood Mission under Ministry of Rural Development have been working in these areas. The above institutions may converge their activities by facilitating identification of units / clusters of STs, SCs, cooperatives, FPOs and SHGs respectively and feed this into state PIPs.

Implementation & Monitoring Mechanism

The Scheme will have the following management structure at the Central, State and District level for effective implementation and monitoring of the scheme:

Inter-Ministerial Empowered Committee (IMEC):

IMEC at the Central level, will be chaired by Minister for Food Processing Industries (MoFPI) for general superintendence, guidance and overall direction for implementation of the scheme, monitoring of progress and reviewing its performance. IMEC will approve scheme guidelines, Project Implementation Plan (PIP) of the State/ UTs under the scheme and various projects of capital investment by SHGs/FPOs/ cooperatives, common infrastructure facilities and proposals of marketing & branding for project size above Rs 10 lakh. A Project Executive Committee (PEC) will be constituted in MoFPI for undertaking administrative function and regular monitoring of the scheme at operational level. A National Programme Management Unit (NPMU) will be set up to assist MoFPI to provide secretarial, managerial and implementation support.



State Level: State Governments would appoint a Nodal Department and a State Nodal officer to oversee the implementation of the Scheme. The Scheme will be implemented by a State Nodal Agency (SNA) assisted by the State PMU. A State Level Approval Committee chaired by the

Chief Secretary will oversee the implementation of the Scheme. The Committee will sanction

expenditure up to Rs 10 lakh on various activities related to the implementation of the scheme.

A District Level Committee (DLC) would be constituted under the Chairmanship of District Collector.

District Resources Persons (DRPs) would be appointed by SNA for providing handholding support to the beneficiaries. Handholding support would be for preparation of DPR, taking bank loan, support for obtaining necessary registration and licences including food standards of FSSAI, Udyog Aadhar, GST etc.

Studies & Reports

State Governments should undertake the following studies:

(i) Base-Line Assessments: A baseline study should be undertaken to identifying ODOP. This study

should get concluded by 31 July, 2020 in each State. For this study, Rs. 2.5 – 10.0 lakh would be provided to the States.

(ii) State Level Upgradation Plan(SLUP): Once decision is taken on the ODOP, detailed studies should be carried out in the States detailing the number of units undertaking processing of that product in the district, farm level of operations, total volume and value of produce, technology, farm gate level processing, storage, warehousing, etc. This study should be concluded by 31 December, 2020. The amount provided for the above study would be Rs. 25.0 – 75.0 lakh to States.

Detailed Guidelines

Detailed guidelines of the scheme can be viewed at Ministry's website mofpi.nic.in

1.2. Status, market size and scope of spices and plantation crop processing in India

Plantation crops are an integral segment of our agricultural economy and are a significant driving force for growth and development of the agrarian economy of many states in India. The major plantation crops in the country include coconut, arecanut, oil palm, cashew, tea, coffee and rubber. Besides, spice crops and cocoa are also considered as plantation crops. The plantation crop sector contributes a significant amount to the foreign exchange and the magnitude of direct and indirect employment provided by the sector makes it vital for overall economic development.

There has been a steady increase in area and production of plantation crops over the last few decades. Presently, the cumulative area under six major plantation crops (coconut, arecanut, cashew, tea, coffee and rubber) comes to 5.12 m ha. Besides, crops like oil palm, cocoa, cardamom, pepper, nutmeg etc. cover an area of 0.60 m ha. The area under these crops was 2.15 m ha during 1970-71 and increased to 3.18 m ha during 1990-91. During the next two decades the area increased by 1.54 m ha.

Similar to area and production, the productivity of the major plantation crops has also shown a steady increase. The increase in productivity is due mainly to availability of improved varieties, better crop production and protection technologies, concerted efforts for technology dissemination and institutional support. The present level of area production and productivity of major plantation crops are provided in Table along with India's share in global production for each of the crop.

Spices are high value and low volume commodities of commerce in the world market. All over the world, the fast growing food industry depends largely on spices as taste and flavor makers. Health conscious consumers in developed countries prefer natural colours and flavours of plant origin to cheap synthetic ones. Thus, spices are the basic building blocks of flavour in food preparations. The estimated growth rate for spices demand in the world is around 3.19%, which is just above the population growth rate. The population increase forecast is up to 1619 millions in 2050 with increased GDP and per capita food spending. As spices are of high value with nutraceutical compounds, its per capita demand may increase many fold by 2050. The projected per capita

demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148 g, 53 g, 1.22 kg and 1.63 kg respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7 to 5.7 folds from the present levels. Therefore, we need to continuously strive to harness the power of intellectual minds and challenge conventional thinking by pushing the boundaries of science to increase spices productivity by enhancing input use efficiency, and reducing post-harvest losses with an eye on reducing the cost of production. We also try to discover effective solutions to emerging problems through conventional and modern science techniques thereby producing spices that will improve the quality of life.

Table 1.1: Present status of area, production and productivity of major plantation crops

Crop	Area	Production	Productivity	India's shares in global production (%)
Tea	0.58 mha	1095.46 million kg	1891 kg ha-1	24.9
Coffee	0.44 mha	304.5 million kg	828 kg ha-1	3.7
Arecanut	0.45 mha	0.61 mt	1364 kg ha-1	46.6
Coconut	2.14 mha	22700 million nuts	10600 nuts ha-1	16.4
Cashew	0.99 mha	0.75 mt	760 kg ha-1	15.7
Rubber	0.52 mha	0.85 mt	1633 kg ha-1	8.1
Oil Palm	0.23 mha	0.86 mt	3.8 tonnes FFB ha-1	1.8
Cocoa	56,500 ha	14,400 tonnes	255 kg ha-1	Neg
Cardamom	92,400 ha	18,400 tonnes	199 kg ha-1	31.2
Pepper	1,24,600 ha	52,600 tonnes	422 kg ha-1	13.8
Nutmeg	18,700 ha	12,700 tonnes	670 kg ha-1	11.1

Source: Directorate of Economics and Statistics, Ministry of Agriculture, GOI and FAOSTAT

CHAPTER 2

POST HARVEST PROCESSING AND VALUE ADDITION OF SPICES AND PLANTATION CROPS

2.1. Post harvest processing and value addition of coconut

Coconut palm (Cocos nucifera L.), a perennial horticultural crop, is a symbol of national and international integration involving more than 93 producing countries and more than 140 consuming countries. It is eulogised as 'Kalpavriksha'- the 'tree of heaven' as each and every part of the palm is useful to mankind in one way or other. There are countless uses of this coconut palm. It is bestowed with multiple benefits like health, wealth and shelter to mankind. It is also denoted as "heavenly tree", "tree of abundance" and "nature's supermarket". The largest producers of coconut are Indonesia and Philippines followed by India. In India, Kerala ranks first in production followed by Tamil Nadu, Karnataka and Andhra Pradesh. These states account for more than 90 per cent of the area and production of coconut in India. However, it is also cultivated with varying success in other states like Assam, Goa, Gujarat, Maharastra, Nagaland, Orissa, Tripura, West Bengal, Andaman and Nicobar Islands, Lakshadweep and Puducherry.

Coconut is mainly consumed as fresh nuts, tender coconuts, coconut oil and copra meal. Around 50 per cent of the world production is consumed in the form of fresh nuts and tender nuts. Close to fifty percent of the nut production is converted into copra and consumed as coconut oil and copra meal. Around 2.52 per cent is consumed as desiccated coconut. The Indian consumption pattern indicates that 56 percent of the produce is utilized for domestic and religious purposes, 35 percent for coconut oil production, 7 per cent for making edible copra and 2 per cent for manufacturing coconut powder. In India, annual consumption of tender coconut is about 200 million. The coconut palm also provides a series of by-products such as fiber, charcoal, handicrafts, vinegar, alcohol, sugar, furniture, roofing, fuel, etc. and it has more than 200 diversified local uses. The products and by-products of these crops form vital inputs for many of the industries and support the livelihood of many millions. They contribute a significant amount to the national exchequer and country's exports by way of excise and export earnings. They also provide direct and indirect employment to a large number of people in the country. The potential of converting

coconut into different emerging value added products such as desiccated coconut powder, virgin coconut oil, coconut chips, coconut milk, preserved tender nut water & coconut inflorescence sap and coconut sugar is realized in view of globalization over the traditional processed products of copra and coconut oil.

Post harvest technologies and machineries

Coconut serves as the basic raw material for a series of agro – processing activities and sustains the lively hood of over 10 million people in the country. The main unit operations in copra processing are splitting, de-shelling and drying. The following machinery has been developed for the benefit of coconut community. The following post harvest machineries are developed by CPCRI to enhance the coconut value addition, product diversification, labour saving etc.

Coconut Splitting Device

To solve the problem of splitting of coconuts by holding it in hand, a manually operated splitting device is developed at CPCRI (Fig.2.1). Knife of the machine is made of spring steel and is kept at a bevel angle of 25 degree. As the cutting blade is made of spring steel, it does not require frequent sharpening. Nut is split manually by the impact force and the nut water is collected at the bottom.

Fig.2.1: Coconut Splitting Device

Dryers

The common practice of making copra is by sun drying the fresh coconut kernel on cement floor or on sand floor for seven to nine days. Unlike in other crops, the endosperm of coconut is exposed while drying and so is susceptible for contamination due to dirt. Prolonged drying, especially during monsoon, also results in microbial infection. The energy efficient dryers developed by CPCRI produce dust and microbial contamination free copra in a short period.

Shell Fired Copra Dryer

The copra dryer (Fig.2.2.) is working on indirect heating and natural convection principles using coconut shell as fuel. This dryer requires less amount of fuel, makes copra in short time and less expensive too. Capacity of the dryer is 1000 nuts per batch. The quality of copra obtained is light brown in colour which fetches good price in the market. The burner

Fig.2.2: Shell Fired Copra Dryer

designed generates heat for 5 hours without tending and the residual heat is retained for one more hour. The average drying time is 24 h.

Solar tunnel dryer

A solar tunnel dryer with a capacity of 1500 coconuts/ batch is developed that produces good quality copra in a shorter time (Fig.2.3.). It consists of a semi cylindrical shape tunnel structure having a transparent cover made from UV stabilized polyethylene film of 200-micron thickness. The solar collector is the black polyethylene film of 250-micron thickness spread on the ground inside the dryer for better absorption of solar heat. The temperature inside the dryer is 20 - 25°C higher than the ambient and the R.H. value is 20 - 22% lower than the ambient. The copra in this is less infested by fungi and bacteria than that produced by open sun drying. Drying time taken to dry copra is 32 sunshine hours. The cost of the dryer is Rs 35000/ and the cost of drying one kg of copra is Rs. 2.15 and for that for pepper is Rs.3. The dryer can also be used to dry other plantation crops produces.

Fig. 2.3: Solar tunnel dryer with electricity as an alternate source of energy

Solar drying relies on the sun as the source of energy. For cloudy and rainy days, a multi source dryer also has been developed with solar energy as the main source of energy and electricity as alternate sources of energy.

Solar cum electrical dryer with agricultural waste as third source of energy:

Solar drying relies on the sun as the source of energy. It generates higher air temperature and consequential lower relative humidity. For cloudy and rainy days, a multi source dryer has been developed with solar energy as the main source of energy and electricity and biofuel as alternate sources of energy. The dryer (Fig.2.4.) consists of a semi circular parallel plate solar collector, electric heaters of 1000 W (6 numbers), blower cum exhaust motor and the drying chamber. It is a auto regulated dryer with temperature and humidity control. It is a batch type dryer and the capacity of the dryer is 2000 coconuts / batch. The dryer can be used to dry other crops such as cardamom and arecanut. Cost of the dryer is Rs. 60000/ and cost of drying per kg of copra approximately Re. 4.5/- if electric heaters are used and Rs.2.70/- if bio fuel is used.

Fig. 2.4 : Solar cum electrical dryer with agricultural waste as third source of energy

Coconut De-Shelling Machine

A power operated batch type coconut de-shelling machine (Fig.2.5.) has been developed to separate

shell and copra after partial drying. Capacity of the machine is 400 half cups per batch. The optimum average moisture content for maximum de-shelling efficiency (92.16 %) is 35 % d.b. The optimum speed of the de-shelling machine is 10 RPM and the time taken for de-shelling is 4 minutes per batch. Estimated cost of de-shelling machine is Rs. 30,000/- and cost of de-shelling 1000 nuts is approximately Rs. 60.00/ 1000 nuts.

Fig. 2.5: Coconut De-Shelling Machine

Copra moisture meter

The quality of milling copra ultimately determines the quality of the oil and the residual cake. Good quality copra will yield oil without refining with a free fatty acid content (FFA) of less than one percent. Moisture is the most important factor influencing the quality of copra. Copra with a moisture content of less than six percent is considered good quality as it is not easily damaged by insects, moulds or microorganisms. At the CPCRI, Kasaragod, an electronic moisture meter was developed (Fig.2.6.) to determine the moisture content of copra, based on the electrical conductivity of the kernel. The instrument can read moisture content from 5 to 40 percent. It is very handy and the accuracy is more than 94 percent in the lower levels of moisture content readings.

Fig.2.6: Copra moisture meter

Tender Coconut Punch and Cutter

Tender nut punch and cutter (Fig.2.7.) are two simple devices to pierce the tender coconut and the cut open it after drinking the water inside. A clean hole sufficient enough to insert a straw is formed and one can drink the fresh water. After drinking the water, the nut is placed on the wooden platform and cut open by pressing the lever attached to the blade. Initial investment of the machines together is Rs. 15,000/-. The efficiency is 20 tender coconuts per hour.

Fig.2.7: Tender Coconut Punch and Cutter

Snowball Tendernut Machine

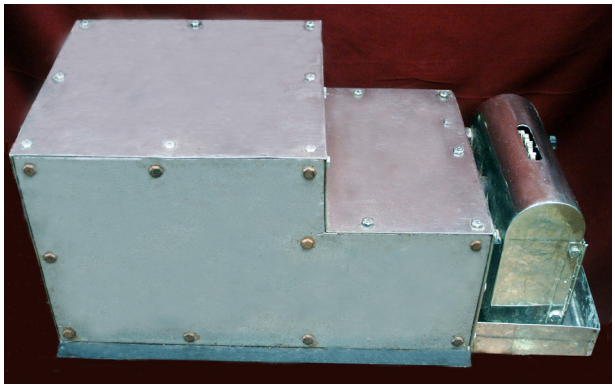


Fig.2.8: Snowball Tendernut Machine

Snow ball tender coconut is globular tender coconut kernel containing tender coconut water inside. The ball scooped out with the help of specially devised tool after cutting the shell of tender coconut of 7-8 months maturity by using snow ball tender coconut machine (Fig.2.8.). The SBTN thereafter is made free of the adhering testa, packed hygienically to use either fresh or after refrigerated storage. Unit cost of the machine is Rs.25000 and output capacity is 250 coconuts in 8 hours by a person.

Coconut Chips Making Machine

Fig.2.9: Coconut Chips Making Machine

Chips making machine (Fig.2.9.) has been developed at CPCRI to slice coconut kernel to make chips. The machine can produce coconut chips of required uniform thickness much faster. The machine consists of two stainless steel slicing blades fixed on a circular blade supporting disc, a feeder to insert coconut endosperm for slicing, an exit guide to guide the sliced coconut chips towards the outlet and an electric motor as a prime mover. The electric motor rotates the blade supporting disc using a V-belt. When coconut endosperm comes in to contact with the blades it gets sliced. The sliced coconut chips are then guided towards the outlet by the exit guide and are collected in a container. Coconut chips of uniform and required thickness could be produced using this machine. Provision is made in the slicer to slice tuber crops, banana and vegetables. Capacity of the machine is 50 coconuts per hour. Fabrication cost of the machine is Rs.50,000/-.

Manually Operated Coconut Slicing Machine

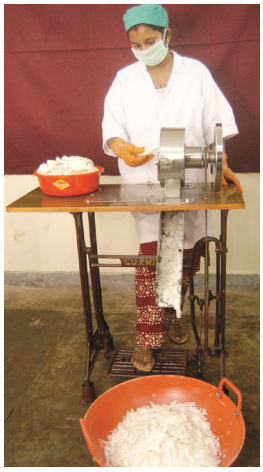


Fig. 2.10: Manually Operated Coconut Slicing Machine

A Manually Operated Coconut Slicing Machine (Fig.2.10.) has also been developed to produce coconut chips. The machine is quite user friendly especially for ladies who knows operation of sewing machine and does not require electricity. Approximately 25 coconuts can be sliced in one hour using this machine. Fabrication cost of the machine is Rs. 15,000/-.

Coconut Chips Dryers

Two types of dryers are developed to dry the sliced coconut kernel to the desired moisture content. The electrical dryer (Fig.2.11.) developed

consists of a set of 10 trays with wire mesh screens for loading coconut slices. Temperature in the dryer is controlled automatically by a sensor and electronic control unit. Though the dryer is designed for 50 coconuts, the size could be enhanced to any desired capacity.

Another prototype of chips dryers that uses agricultural waste as fuel (Fig.2.11.) has been developed. Furnace of this indirect dryer is conveniently placed outdoor and the drying unit indoor. Temperature is controlled by a butterfly valve in the hot air inlet. Cost of drying would be less than that of electrical dryer.

Fig.2.11: Electrical and Agricultural waste fired coconut chips dryer

Coconut Testa Removing Machine

Testa removing is an important operation during the process of making many high value coconut products like desiccated coconut, virgin coconut oil, etc. Traditionally testa is removed using a hand held tool similar to 'potato peeler' or by a knife. Both the methods are cumbersome and time consuming. The Coconut testa remover is a circular wheel covered with an emery cloth or water paper attached to a prime mover, an electric motor (Fig.2.12.). One person can remove testa of about 75 coconuts per hour. Fabrication cost of the machine is Rs.25, 000/-.

Fig. 2.12: Coconut Testa Removing Machine

Coconut Grating Machines

Two coconut gratings machines were developed to enhance the grating efficiency. First one is of single user

(Fig.2.13.) and the second one is of multi user (four grating blades) type (Fig.2.14.). The motorized coconut grating machines developed scrapes off the deshelled coconut flesh into fine gratings with the help of stainless steel blade. The single user machine has a capacity of 60 nuts/hr and the multi user has a capacity four times of the first one.

Fig. 2.13: Coconut Grating Machine-Single user

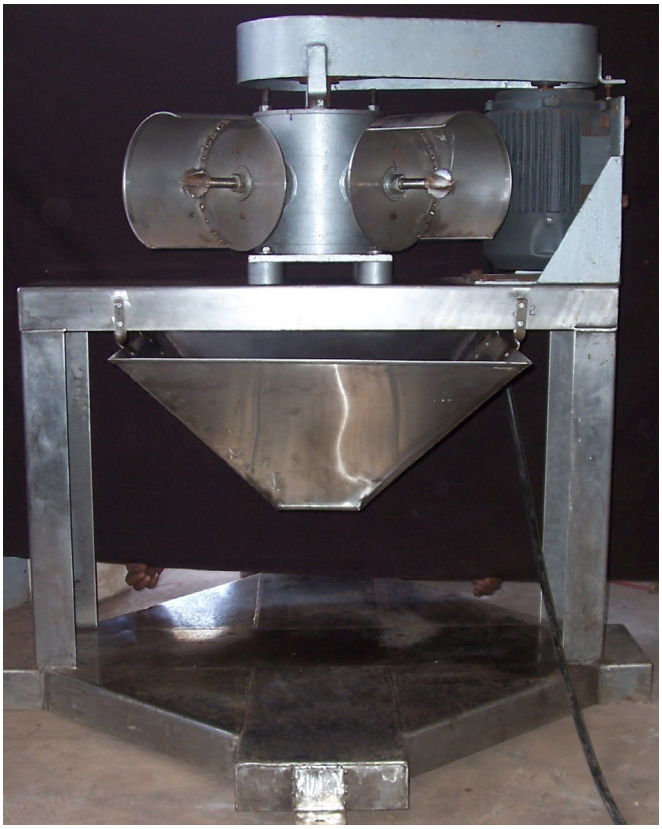


Fig. 2.14: Coconut Grating Machine-Multi user

Coconut Milk Extractors

Four different coconut milk extractors are developed to enhance the milk extraction efficiency. Two are manually operated and two are hydro pneumatic coconut milk extractors.

Manually operated

Both the manual operated machines (Fig.2.15.) are similar to a hand operated vertical screw press. The grated coconuts are kept in a perforated cylinder and by rotating the handle provided at the top of the screw the gratings are pressed. In the first machine the whole pressing process

Fig. 2.15: Manually operated Coconut Milk Extractors

is done manually by rotating the handle. In the second machine an additional hydraulic jack is provided at the bottom.

Hydro Pneumatic Coconut Milk Expellers

Two hydro pneumatic coconut milk extractors (Fig.2.16.) of different capacities were also developed for large scale extraction of coconut milk. The operation of both the machines is completely automated using a programmable logic controller circuit. The user can programme the machines using the programmable logical controller as per his requirement.

Fig. 2.16: Hydro Pneumatic Coconut Milk Expellers

Screw Type Coconut Milk Expellers

Two screw type coconut milk expellers, single (Fig.2.17.) and double (Fig.2.18.) screw, with different capacities have been developed to extract coconut milk. The screw type expellers have the maximum extraction efficiency among different types of coconut milk extractors. The third expeller is a single screw type with an inbuilt cooling mechanism (Fig.2.19.) to extract coconut milk at room temperature.

Fig.2.17: Single Screw Coconut Milk Expeller

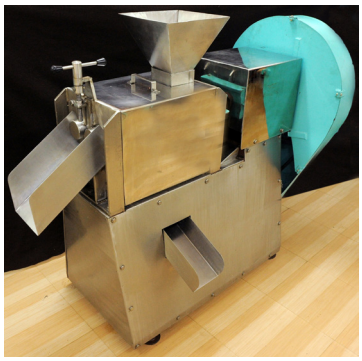


Fig.2.18: Double Screw Coconut Milk Expeller

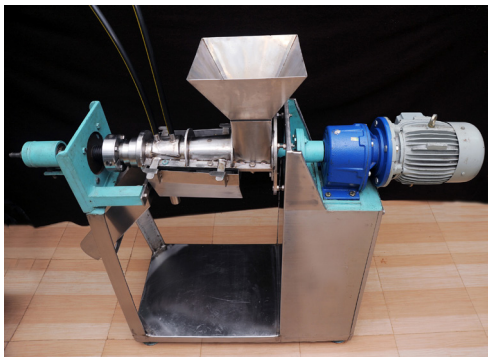


Fig.2.19: Single Screw Type Coconut Milk Expeller with cooling mechanism

Virgin Coconut Oil Cooker

The Virgin Coconut Oil Cooker (Fig. 2.20.) developed by the institute consists of a double jacketed vessel filled with thermic fluid. The thermic fluid ensures efficient and uniform heat transfer to coconut milk kept in the cooker. Four Teflon tipped stirrers are provided to stir coconut milk. This helps the cooker to distribute heat energy uniformly within the coconut milk kept in the cooker. The stirrers are powered by an electric motor with a reduction gear. An outlet with a door attached to a lever is provided at the bottom of the cooker to take out the extracted oil. A thermometer is provided to measure the temperature of the thermic fluid so that it can be kept from 100-1200C. A safety valve is provided for releasing the pressure developed, if any, in the thermic fluid chamber. The cooker is heated by two burners provided at the bottom of the heating chamber. Biogas or LPG could be used as fuel. Virgin coconut oil cookers of any capacity could be fabricated. Virgin coconut cil cooker given in the drawing is of 125 litre capacity and cost Rs. 2,25,000/- for fabrication including material cost.

Fig. 2.20: VCO Cooker

Copra

Among the different kernel products, one product that could be produced at the farm level is edible copra in the forms of ball and cup. It is common practice to store or season the harvested nuts before they are further processed. The advantages of storage or seasoning of harvested nuts are 1) decrease in moisture content, 2) increase in thickness of copra, 3) increase in oil content, 4) greater meat resistance to bacterial sliming while sun drying, 5) easier husking, 6) cleaner and easier shelling, and 7) uniform quality of copra. Ball copra is made from fully matured whole unsplit nuts. In some states in India, the farmers produce ball copra by storing fully ripe whole nuts at each harvest on raised platform erected within the house or in a separate shed until the nut water is completely absorbed and the kernel becomes dry and detaches itself from the shell. At this stage, the nut is dehusked and the loosened kernel is taken out in the ball form after carefully breaking and removing the shell. This practice is prevalent among the different categories of farmers, whether small or large, as it is possible to store any number of nuts at a time depending on availability of space and facility for storing in the household.

Edible cup copra is also produced by different drying methods. Drying must be carried out within four hours of splitting since coconut kernels deteriorate very rapidly due to growth of mould and bacteria. The methods generally used for drying of copra are sun drying, smoke drying or kiln drying and drying by mechanical means. To obtain good quality white copra, particularly during rainy season, a suitable dryer using indirect heating is essential. The existing direct type kiln dryers are not desirable as the product becomes inferior in quality due to smoking and improper drying. To overcome these problems, shell fired copra drier and poly house solar driers developed by ICAR-CPCRI are being used.

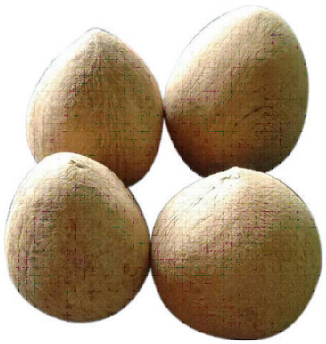
In some countries kernel chips are produced by slicing the wet kernel into thin, even sized pieces and toasting under controlled temperature. Both salted and sweetened chips are produced depending on local demand for use as snack food. The product is marketed in moisture proof containers. It is not difficult to organize this as a household activity under the aegis of farmers' cooperatives. The edible ball copra is also a good material for producing kernel chips.

Main end product of dry processing is copra and coconut oil. Copra drying is one of the major unit operations in dry processing. Fresh coconut kernels contain 50-55% moisture content, which is to be brought down to 5-6% by drying. Converting coconut into copra can yield 15% more income and copra to coconut oil can fetch another 10% income to the farmer.

Ball copra

Ball copra is made from fully mature (>12 months) whole unsplit nuts. The nuts are stored for about 8 to 12 months on a raised platform, usually made of bamboos, inside a shed. During this period, the coconut water slowly gets absorbed and the kernel dries out and loosens itself from the shell. The nut at this stage is dehusked and the shell carefully removed to separate the whole dry kernel in the ball form. In some places, drying process is hastened by occasional heating of the nuts by a slow fire set under the platform.

Ball copra is soft, sweet, oily and cream coloured. Three grades of ball copra are available on weight basis viz. 'large', 'medium' and 'Small' depending on the number of copra required for a weight of four kg (<20 for 'large', 20-40 for 'medium' and >40 for 'small'). The moisture content shall in all cases be below seven percent. This grading is being accepted generally in the marketing sector now.



Preparation of ball copra by heat treatment

In order to reduce the incubation period to the minimum, coconut is partially dehusked and heated in small holder's dryer at 550C -600C for eight hours daily for three days and stored in gunny bags for 10 days. This intermittent heating is repeated till all the nuts become ball copra. All the nuts under heat treatment become ball copra within six months and the quality of the ball copra is also very good. In conventional method, it takes 11 months. In a similar way, puny nuts under heat treatment are transformed into ball copra within three to four months. Conversion of nuts into ball copra is faster during January to May compared to June to November period (Madhavan and Bosco 1991).

Cup copra

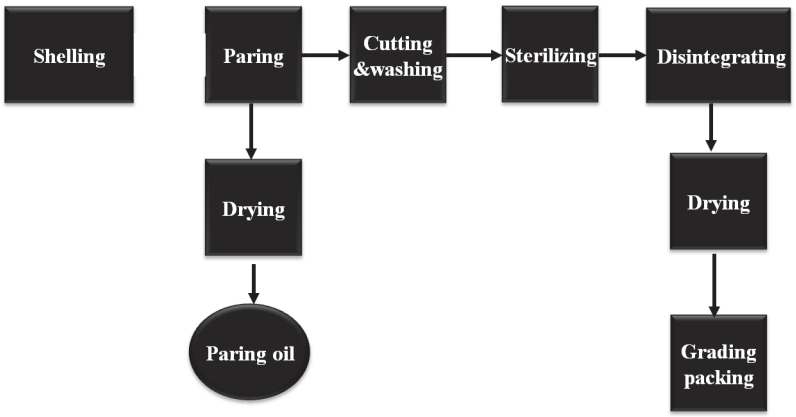
Edible cup copra is prepared either from fully matured nuts or from stored nuts by cutting the dehusked nuts into halves and drying them in the sun. The cutting, drying and deshelling processes are done very carefully in order to get a good clean final product. In Sri Lanka and in some parts of India, hot air driers are used for the production of edible type of cup copra. In some copra markets

in India, good quality cups of uniform size are separated from bulk gatherings of commercial copra and marketed as edible copra at a premium price.

In Kerala, India, cup copra is classified into three grades. The major grade is 'Rajapur' copra. Here, the ball copra where the kernel is completely dried out is cut into two and dried in the sun for three days. The second grade is called 'Malathi' where partially dried ball copra is cut and dried in the sun for seven days. The third grade is known as 'Dil Pasand'. Nuts harvested and kept for two to three months are used for preparing this type of cup copra. Freshly harvested nuts also can be used. Nuts are split and dried in the sun for more than seven days. Adequate care is taken in splitting the nuts and drying. Neat white copra cups separated from the bulk of milling copra are also sold as 'Dil Pasand' after trimming the edges.

Desiccated Coconut

Shredded and dried white kernel or endosperm is marketed as desiccated coconut. It is rich in healthy medium chain fatty acids with no cholesterol and an excellent source of dietary fibre. The steps involved in processing of desiccated coconut involves selection, sorting and husking of coconuts, shelling, paring, washing, sterilizing, grinding, drying, sieving, packing, and storage. The main uses of desiccated coconut are for the confectionary industry, as a filling for chocolates and candies; the bakery industry for biscuits, cake and nut filling products; direct usage to decorate cakes, biscuits and ice cream and preparation of various snacks. Over the last few years, import of desiccated coconut across the world grew by 19% in value and 4.1% in quantity, which provides opportunities for new suppliers from developing countries. Though India is the largest producer of raw coconut in the world, export of desiccated coconut is only to the tune of less than one percent of the global demand. Nevertheless, during the year 2015-16, India exported 4261 MT desiccated worth rupees 52.60 crores. In comparison with the export figure of previous year, India achieved an increase to the tune of 60%, which indeed a remarkable achievement. There exists an immense export potential for the desiccated coconut across the world. The flow chart of desiccated powder preparation is described below,



Specification (IS : 966 -1975)

Specification	Requirement
Moisture, per cent by mass, Max.	3.0
Fat, per cent by mass, Min	65%
Fat acidity, as lauric acid, Ma x.	0.3%

Techno economic details

Machineries required	Coconut dehusker, desheller, testa remover, washing unit, inspection conveyor, blanching unit, pulverizer, fluidized bed dryer, desiccated powder cooler, lump breaker, vibro siever, packaging unit.
Capital Investment	Rs.130 lakhs for processing 15,000 nuts per day
Yield	1 ton from 10,000 coconuts

In India, 8000 to 9000 nuts yield one tonne of desiccated coconut. While the general figure in Sri Lanka is about 7000 nuts and in certain tracts, particularly in Chilaw District, 6000 nuts will give one tonne of desiccated coconut. In the Philippines only 5500 selected nuts are needed to produce one tonne of desiccated coconut in most of the producing areas.

Coconut oil

Coconut oil is one of the major edible products of coconut. This is referred as lauric oil in the world market because of its high lauric acid content. It is very heat-stable, and s uitable for cooking at high temperatures for frying. It is slow to oxidize and resistant to rancidity for up to two years due to its high saturated fat content. Coconut oil is used in India for culinary/edible, toiletry, soap making and as an illuminant and lubricant. Coconut oil is used for various purposes i.e. edible (39.4 %), toiletry (46.5 %) and other industrial (14.1 %) uses.

The fresh kernel is dried to less than 6 % moisture (copra) which is then expelled to get coconut oil. Copra is cut into small chips in a copra cutter. The chips are fed into steam jacketed kettles and cooked mildly at a temperature of 70oC for 30 minutes. After proper cooking, the cooked material is fed into the expeller continuously and pressed twice. The combined oil from the first and the second pressing is collected in a tank provided separately. This oil is filtered by means of a filter press and stored in MS tanks and then packaged in Bulk packaging is done in tin containers. HDPE containers and polymeric nylon barrier pouches are used for consumer packaging.

Specification (IS-542-1968)

	Specification	Requirements
	Moisture % wt., Max.	0.25
	Colour in 1/4 cell Lovibond Y+5R, not Deeper than	4
	Acid value, Max.	2.0
	Unsap. matter % by wt., Max.	0.8
	Polenske Value, Min.	0.8

Techno economic details

Machineries required	Copra cutter, bucket elevator, steam jacketed kettle, oil expeller, screw conveyor, crude coconut oil storage tanks, filter press, micro filter, filtered oil storage tank, baby boiler, packaging unit.
Capacity	5 tonnes copra/day
Yield	3 tonnes oil
Total project cost	Rs.72 lakhs for 3 ton/d capacity
Plant & Machinery cost	Rs.25 lakhs
Annual sales turnover	Rs. 315 lakhs
Net profit	Rs. 12 lakhs
Return on investment	28%

Coconut Cake

Traditionally coconut is dried to produce copra which is then milled or solvent extracted to get the oil. Fresh coconut kernel contains about 4 to 4.5 percent protein. Major portion of the original protein passes on to the coconut cake or poonac, which is the residual product after oil extraction. It forms about 32 to 40 per cent of the copra after the extraction of oil. The output of cake and its final composition, depend upon the extraction methods employed. The cake however is not considered suitable as a protein supplement because in the process of oil extraction, the original protein gets discoloured and denatured due to the generation of very high temperature. Hence it is mainly used in ruminant feeding.

Table 2.1: Composition of coconut cake

	Expeller cake	Solvent extracted meal
Moisture	7.0	8.9
Fat	6.7	2.4
Protein (N x 6.25)	21.2	21.4
Nitrogen-free extract	47.4	47.4
Fibre	11.2	13.3
Mineral matter	6.5	6.6

Coconut cake is also useful for feeding poultry. The cake easily absorbs atmospheric moisture while in storage and consequently, is prone to mould attack. The equilibrium moisture content of the cake at 40 to 70 per cent, 80 per cent and 90 per cent relative humidity of the atmosphere are 10 per cent, 20 per cent and 30 per cent respectively.

In India, a study on the shelf life of coconut cake revealed that the moisture content of the cake at 79 per cent RH was 15.2 percent and this was the critical moisture content at which it can be stored free from moulds. The study also showed that the cake could be stored without any spoilage up to about six months if alkathene bags or alkathene lined containers are used. The rancidity of the cake could be effectively checked if its moisture content is kept below the critical level of 15.2

per cent.

Coconut cake is sometimes used as manure for field crops. But the cake has a high carbon nitrogen ratio and is, therefore, not considered suitable for manuring seasonal crops. Coconut cake contains three percent nitrogen, 1.9 percent phosphorus pentoxide and 1.8 percent potassium oxide. As the nitrogen, phosphoric acid and potash contents of coconut cake are not high, it is not considered as valuable organic manure.

Coconut milk

Coconut milk is essentially an oil-in-water emulsion, stabilized by the naturally occurring proteins (globulins and albumins) and phospholipids (lecithin and cephalin). In comparison with dairy milk, coconut milk is richer in fat, poorer in protein and sugar. Coconut milk can be used in curry preparation, confectionaries etc. It is utilised as a substitute of dairy cream in beverage type milk, as evaporated and sweet condensed milk and in the preparation of white soft cheese, Yoghurt and many other food stuffs. The proximate composition of coconut milk as reported by the Central Food Technology Research Institute (CFTRI) Mysore, India, is given in Table 2.2.

Table 2.2: Proximate composition of coconut milk

Constituent	Percentage
Moisture	4.10
Protein (N x 6.25)	5.8
Fat	38 to 40
Minerals	6.2
Carbohydrates	9 to 11

Various primary and secondary processing are involved in packaged coconut milk production. It includes, dehusking, deshelling, testa removal, pulverizing milk extraction, pasteurization, homogenization and packaging. The flow chart of packaged coconut milk is given in Fig.2.21. About 2500 kg coconut milk can be obtained from 10,000 nuts

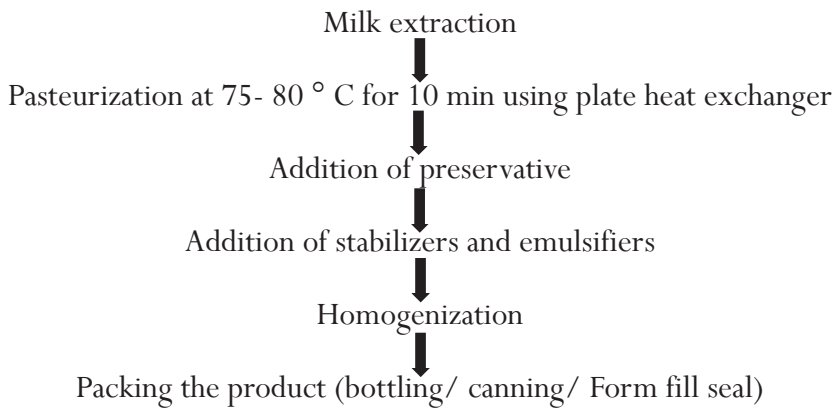


Fig. 2.21: Flow chart for coconut milk packaging

Techno economic detail

Machineries required	Hammer mill, elevator, screw press, coconut milk storage tanks, vibrating sieving machine, coconut residue mixer, additive mixing tank emulsifier, homogenizer, pasteurizer, volumetric filling machine ,exhaust box, can seaming machine, horizontal rotary retort, hot air drier, agro waste vertical boiler, sterilization tank, coconut residue storage bins.
Capacity	10,000 mature coconuts/day
Land	1 acre (cost variable)
Building - 6000 sq.ft @ Rs.1000 per sq.ft.	Rs.60 lakhs
Plant & machinery (does not include DG set, weigh bridge, effluent treatment equipments and other items not directly connected with process operation)	Rs.75 lakhs
Electrification	Rs.25 lakhs
Preliminary and pre-operative expenses	Rs.15 lakhs
Margin money for working capital	Rs.40 lakhs
Yield	2,500 kg coconut milk/ 500 kg coconut cream residue-

Fig. 2.22: packaged coconut milk

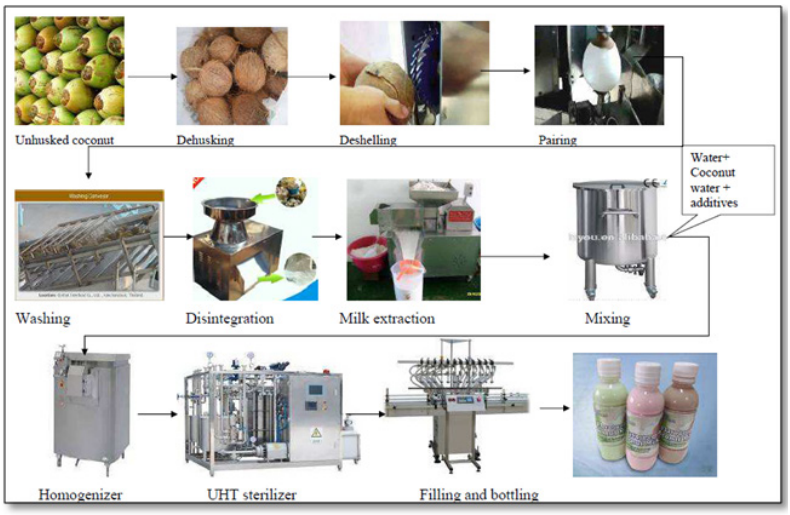
Bottled coconut milk

The processing technology involves extraction of milk from coconut, straining the milk in a cheese cloth into an aluminium kettle with 0.1 percent benzoic acid before placing the kettle in an autoclave at 117oC for three minutes with steam injection. The temperature of the milk in the pot is then brought down to 80-85oC, by running tap water. The milk is then homogenised for about five minutes and bottled at 70oC to 80oC. The final product is as good as cow's milk and is highly nutritious.

Coconut flavoured milk

Coconut milk is vegan alternative to dairy milk. Coconut milk does not contain lactose and is lower

in carbohydrates than dairy milk, which can be consumed by people who are lactose intolerant or just don't enjoy the taste of dairy milk. Milk is extracted from freshly grated coconut of 9-10 months old. Extracted milk is clarified to remove suspended solids which are present in the milk. Coconut milk is then mixed with coconut water and diluted by adding purified drinking water until it is appropriate for flavoured coconut milk production. It is then mixed with 10-12% sugar, 2% stabilizers, emulsifiers and flavours. The flavoured coconut milk is then UHT sterilized at 138-140°C for about 15 seconds, which is then packed in sterilized polypropylene bottles



(Source: http://coconutboard.nic.in/process.htm)

Fig.2.23: Flow chart of Flavoured coconut milk processing

Specification

Total soluble solids (%)	20-22
Total Fat (%)	0.92
Total Fat (%)	0.92
Carbohydrates (%)	17.33
Protein (%)	1.42
Minerals (%)	0.40

Techno economic details

Machineries required Dehusking, deshelling, testa removing, blanching, pulverizing, milk expelling, filtration, mixing with water and additives (10-12% sugar, 2% stabilizer, emulsifier and flavors) , Agitation, Homogenization, UHT sterilization (140C for 15 sec), filling in the sterilized PP bottle and sealing.

Machineries required	Dehusking, deshelling, testa removing, blanching, pulverizing, milk expelling, filtration, mixing with water and additives (10-12% sugar, 2% stabilizer, emulsifier and flavors) , Agitation, Homogenization, UHT sterilization (140C for 15 sec), filling in the sterilized PP bottle and sealing.
Capacity	5,000 coconuts/ day
Yield	4000 litres flavoured milk

Cost of plant and machinery	Rs.132 lakhs
Total project cost	Rs.2.23 crores
Pay back period	4.5 years
Internal rate of returns	19%
Break even point	49%

Preserved coconut milk

Preserved forms of coconut milk such as canned cream or milk and dehydrated whole milk are now becoming available in many countries. Commercial production of these products has been promoted in Philippines, Thailand, Indonesia, Western Samoa, Sri Lanka and Malaysia.

The technology for the production and preservation of coconut milk has been perfected in India. In this process, pared kernels are first immersed in hot water for 10 minutes at 75 to 80°C for microbial control. The kernels are then comminuted either using the hammer mill (three mm) or the Krauss Maffei disintegrator with three mm perforation. The optimum maturity of nut for achieving maximum yield of milk was found to be 11 to 12 months. The moisture content of the gratings is maintained at 40 to 45 per cent for facilitating efficient extraction of milk. Pressure is applied on the comminuted kernel with or without the addition of water. The extraction of milk is done in a screw press. The extracted milk is passed through a vibratory sieve of 150 microns to ensure that the milk finally contain not more than 0.5 per cent of the finely grated material. The milk is then pasteurized at 75 - 80°C for 10 minutes using a plate heat exchanger. As an adjunct to heat treatment, sodium metabisulphite or the antibiotic nisin is used to enhance the shelf life of the finished product. After pasteurization, stabilizers and emulsifiers are added to the milk for preventing the separation of the milk and for facilitating emulsion formation. Carboxy methyl cellulose (CMC) and guar gum were found to be good stabilizers. Among the emulsifiers tried, Tween 80 at 0.1 - 0.2 per cent levels were found suitable in the presence of 0.5 per cent CMC. The pasteurized milk is then passed through a colloidal mill and pressure homogeniser for the coagulum dispersal and the even distribution of emulsifiers and stabilisers. Pressure homogenization at 4000 psi has been found to impart better stability to the finished product. For packing the product, hot filling and crown corking are presently followed. Other packing systems like flexible packing and canning are also found successful. The analytical data of the coconut milk produced in India are shown in Table 2.3.

The technology developed in the Philippines has been patented under the Philippines Patent No. 5632. In this process, round mature nuts are selected and deshelled. After disintegration, the meat is mixed with one and a half to two times its weight of water and passed through a screw press or expeller to extract the milk. The extracted milk is centrifuged to separate the cream from the watery and solid portions of the extract. The cream is then mixed with water (half to two times its weight) and pasteurized for 15 to 30 minutes. The pasteurized cream is thoroughly mixed with sodium caseinate at 0.5 per cent level to stabilize the cream and then homogenized. The homogenized mixture is then heated almost to boiling point and filled in cans or bottles and autoclaved at 115.5°C for 40 minutes. The tin cans are cooled immediately by submerging in

a cooling tank with running water before packing in carton boxes. In the process developed in the Philippines, the watery phase or skim milk is wasted as a result of centrifugation. In order to eliminate this wastage, a process to preserve the whole milk has been developed with the use of additional stabilisers. Both canned coconut cream and processed whole milk have been found to enjoy very high consumer acceptability. The composition of these products is given in Table. 2.3.

Table 2.3: Composition of canned coconut milk products (in percentage)

Properties	Moisture	Protein	Fat	Carbohydrates
Canned cream	55.0	0.9	40.0	2.8
Canned whole milk	75.0	1.0	12.5	10.2

The chemical composition and quality of coconut cream varies widely in different countries. The tropical products Institute, London reported that the organoleptic qualities of a number of samples tested were inferior to those of freshly prepared cream, due to excessive heat treatment. As such, the TPI has standardised the processing technology with optimum heat treatments and judicious use of added emulsifiers and stabilisers. Here the coconut milk is first clarified at a temperature of about 45°C in a centrifugal clarifier at 10,000 rpm. The clarified emulsion is fed to a centrifugal separator at a rate of 425gph and a temperature of 38°C by a centrifugal pump fitted with a 0.5 HP motor to separate the cream and the aqueous phases. The cream is then diluted with the aqueous phase to obtain three different concentrations (low, medium and high fat) and the creams are heated to 55°C and an emulsifier/ stabilizer mixture of Triodan 55 (1% W/W) and bleached soya lecithin (0.1% W/W) is added with thorough mixing. The formulated creams are then subjected to a two-stage homogenization, one at 3500 psi at 50oC and the other 1oC at 500 psi. The cream is then heated to 60 oC using a water bath arrangement, canned and sealed.

In Thailand, coconut meat is soaked in sodium metabisulphite solution prepared by dissolving one gram of sodium metabisulphite in water for every coconut, for one or two hours or overnight. After washing, the meat is grated and milk extracted using an expeller or screw press. The milk is evaporated at 60°C to 70°C in a steam jacketed kettle equipped with a blade, rotating at 20 rpm with constant stirring for four to six hours. About 600 ppm sodium metabisulphite and 240g pectin for every 100 coconuts are then added to the milk concentrate. Finally the milk concentrate is pasteurized at 70°C for one or two minutes. The concentrated cream is packed in sterilized lacquered tin cans or sterilized aluminium tubes at 70°C, each containing 160 to 170g net. The final product is greyish white in colour which turns white upon dilution with water. It has a proximate composition of 10 to 11 per cent moisture, 76 to 80 per cent fat and six to seven per cent protein. About 130 kg unhusked coconuts yield about 32 kg of processed cream.

In the process adopted in Malaysia, the pared kernels are sterilized in boiling water for 1 to 1.5 minutes prior to pulverization and extraction of milk. The milk is concentrated in a steam jacketed kettle @ 80°C for 12 to 14 hours with continuous stirring. Sodium metabisulphite at 600 ppm is also added as a preservative. The product which is thick in consistency with 40-45 percent fat is packed both in cans and plastic pouches. In Western Samoa, fresh nuts within three days of harvest are utilised for processing. The pared kernels are grated and the milk extracted in a screw press.

The milk is diluted in the ratio of 2:1 and sterilised in a steam jacketed kettle for about 30 minutes. The cream is subsequently homogenised while hot, canned and sealed. One hundred and eighty kg of unpared coconut kernel yields about 127 kg cream. In Singapore, the processed milk is packed in cans, tetra pack and combine packs. Besides coconut cream, various milk shakes like fruit juice, coconut water and to a small degree coconut cream are also produced in Singapore. In a study conducted in Indonesia, it was found that 160 g of cream was enough to satisfy the requirements of an average Indonesian family normally using four coconuts a day.

Coconut cream

Coconut cream is the concentrated form of milk extracted from fresh matured coconuts. It is a white, smooth, liquid cream with excellent coconut flavour and 20-30% fat, aseptically packed. This is an instant product, which can either be used directly or diluted with water to make curries, sweets, desserts, puddings, etc. It is essentially used as a fat source for the reconstitution of the skimmed dairy milk and as a component of infant milk powders. It can also be used in manufacturing bakery products and flavouring foodstuffs. About 10,000 mature nuts could yield about 2500 kg of coconut cream and 500 kg of residual grating.

Coconut cream is mainly used as a fat source for the reconstitution of the skimmed dairy milk and as a component of infant milk powders. In the Philippines, the cream could be successfully included as a component for the production of recombined milk or filled milk into three types of milk products- beverage type, evaporated type and sweetened condensed type. It was found that about 60 per cent of coconut milk can be used as cow's milk extender in processing white soft cheese. The product was comparable to that obtained from 100 per cent cow's milk in flavour, aroma, texture and general acceptability. The shelf-lives were two days and one week at ambient temperature (25 - 30°C) and refrigerated temperature (5°C), respectively.

Coconut skim milk

Coconut skim milk is a solution of the soluble components of coconut after the cream is separated in a cream separator. Skimmed milk is a good source of quality protein suitable for the preparation of many useful food products or as supplemental protein source, especially in regions deficient in animal proteins. Freshly prepared coconut milk from pared kernel is filtered through a 120 mesh vibrating screen and the pH of the filtered milk is raised from 6.3 to 7.0 with the additions of sodium hydroxide. The milk is then pasteurized at about 60"C for one hour and subsequently centrifuged in a cream separator to yield the aqueous phase or the protein rich skim milk. Skim milk can be concentrated to a protein rich non-fat solid-product for industrial use. Skim milk can be used for the production of a variety of products like spray dried powder, coconut honey, coconut jam and sweetened condensed milk.

Sweetened condensed coconut milk

Coconut skim milk can be used in the preparation of sweetened condensed coconut milk. Powdered dairy skim milk is added for protein fortification and other ingredients are corn oil, coconut cream and sugar. The skim milk is first pasteurized for 30 minutes at 80-90oC and mixed

with other ingredients. The mixture is blended or passed through a colloid mill, and heated in a steam jacketed kettle with constant stirring to a TSS content of 68%. It is packed hot in sterile tin cans and cooled immediately in cooling tanks. It contains protein (5.53 per cent), fat (10.35 per cent), carbohydrates (60.68 per cent), calcium (112.62 mg per cent) as well as magnesium, iron, zinc and manganese.

Vegetable casein

Skim milk is also a source of vegetable casein. In Brazil, the gastro-intestinal disturbances were successfully treated in infants by feeding coconut milk, which shows that coconut skim milk having the same protein level (1.6 per cent) as mother's milk is well- absorbed by infants. Both produce a soft curd when acted on by the gastric juice.

Low fat coconut jam

Skim milk is also utilised for the production of low fat coconut jam. The whole milk is subjected to centrifugation for the separation of skim milk. For every 20 kg skim milk, 3.75 kg of brown sugar and 1.25 kg of glucose are added and the mixture is boiled for 20 minutes, blended, strained and boiled again. Citric acid is added just before cooking is complete and boiling is continued to an end point of 75 to 76 per cent total soluble solid content as measured with a hand refracto meter. The hot jam is poured in sterilised containers and sealed hermetically.

Dehydrated coconut milk

This is produced on a commercial scale in the Philippines and Malaysia. In Philippines, the fresh coconut milk is blended with small amounts of additives such as maltodextrin or casein and is spray dried. The final product is marketed in laminated foil bags. The powder is easily dissolved in water to form a milky white liquid obtaining the flavour and texture of coconut milk. It is suggested to mix or blend 100 g powder with 120 ml water to make coconut cream. About 1000 kg of endosperm would yield 450 kg powder. The product contains 692 calories, 60.5 per cent fat, 27.29 per cent carbohydrates, 9.6 per cent protein, 1.75 per cent ash, 0.8 to 2.0 per cent moisture and 0.02 per cent crude fibre. In Malaysia, coconut milk powder is marketed in the domestic markets as 'Santan' and in overseas markets as coconut cream powder.

Coconut milk powder

Coconut milk powder is the dehydrated form of the coconut milk. This product has a good keeping quality and retains the natural flavor, texture and taste of coconut milk. It is prepared by spray drying the coconut milk along with homogenizer and emulsifier and without any preservative. The process involves to make coconut milk powder are deshelling, paring, disintegration of the kernel, squeezing the comminuted kernel in a screw press, standardization of coconut milk with maltodextrin and sodium cassienate, pasteurization, spray drying and packing in aluminum packets. The powder is easily dissolved in

water to form a milky white liquid with the flavour and texture of coconut milk. To make coconut cream, it is suggested to mix or blend 100 g powder with 120 ml water.

Spray Dried Coconut Milk Powder

Spray drying method is used for the commercial production of coconut milk powder. The product packed in laminated foil bags, contains 62 per cent fat, 14 per cent protein and 2 per cent moisture which can be used in place of fresh coconut milk for food preparation / beverages in household and food industries. Additive such as maltodextrin, casein or skim milk or corn syrup are added to the extracted milk and the mixture is pasteurized and homogenized before spray drying. Such additives aid the spray drying process and help to convert a high fat coconut milk into flowable, but cohesive powders through encapsulation of fatty substances. It can be reconstituted into coconut milk by diluting with water. It offers additional advantage such as less storage space, enhanced shelf life and reduced packaging cost. Central Food Technological Research Institute, Mysore with the financial assistance of the Board has developed the technology for spray dried coconut milk powder.

Specification

Specification	Requirements
Moisture	2%
Fat	66 - 72%
pH	5.8 - 6.5
FFA	0.2% max
Density	0.3 - 0.45 g/cc

Techno economic analysis

Machineries required	Hammer mill, Coconut Milk extractor/ screw press, coconut milk storage tanks, additive mixing tank, pasteurizer, homogenizer, spray drier, elevator, vibrating sieving machine, volumetric filling machine, horizontal rotary retort, sterilization tank, can seaming machine, agro waste vertical boiler, coconut residue mixer etc.
Capacity	20,000 coconuts per day
Land	60 cents
Building - 6000 sq ft.	Rs.45 lakhs
Plant & machinery	Rs.200 lakhs
Contingencies	Rs.10 lakhs
Preliminary & pre-operative expenses	Rs.15 lakhs
Working capital (Margin money)	Rs.25 lakhs
Yield	1 tonnes of coconut milk powder

Fermented beverage concentrate

This is a type of cultured milk using skim milk as a substrate and Lactobacillus bulgaricus as a starter culture. This product has been commercially prepared in many countries and named as 'Calpis' in Japan and 'Bulgaricus milk' in Bulgaria. Milk is pasteurised at 90°C for 30 minutes in a water bath, cooled to 40°C and inoculated with 3 percent culture of Lactobacillus bulgaricus. The mixture is incubated at 37 - 38"C for 24 hours. Curdled milk is homogenised for five minutes and heated to 60°C before the addition of sugar. Sugar is then added in the ratio 1: I. The mixture is further heated to 80°C and cooled down to 60°C, then 0.5 percent flavoured extract is added. The finished product is bottled and pasteurised in water bath at 70°C for 30-60 seconds. Based on sensory evaluation, 50 per cent of coconut skim milk and 50 per cent of non- fat dry milk ratio is found as the most acceptable formulation. This is a highly nutritious drink suitable for kids and adults alike. Unlike carbonated drinks, the fermented beverage contains proteins. It is non-fattening and easily digestible and is a perfect beverage for those suffering from digestive ailments. Similar products have been commercially prepared in other countries, for example, 'Calpis' in Japan and 'Bulgaricus milk' in Bulgaria.

Coconut yoghurt

Yoghurt is a fermented product obtained by the fermentation of cow milk using lactic acid bacteria such as Streptococcus thermophiles and Lactobacillus delbrueckii spp. Bulgaricus. Yogurt from coconut milk can also be consumed by lactose intolerant. One liter of coconut milk was preheated at a temperature of 90°C for 3 min. It was then cooled till the temperature reduced to 40°C. 3% inoculum was mixed to the coconut milk and the cultured coconut milk was incubated at 37°C for 8 hours then it was stored at 4°C. A combination of soymilk (50%) and coconut milk (50%) has also been used in the preparation of soy coconut yoghurt. Coconut milk can also be used along with cow milk to produce acceptable and affordable yoghurt.

Coconut cheese

White soft cheese can be made from a mixture of 40% skimmed milk and 50% coconut milk which will have the same flavour, aroma, texture and acceptability as 100% cow's milk cheese. Fresh kernel is grated and pressed to extract milk. Coconut milk is allowed to stand for eight hours until the cream is collected at the top. The cream is slowly scooped out and the skimmed milk heated with vinegar to coagulate the proteins. The coagulated protein is mixed with the cream and kneaded with salt.

Coconut syrup

Coconut syrup, a translucent, free-flowing liquid is prepared by cooking homogenized coconut milk with an equal amount of refined sugar and di-sodium-phosphate equivalent to 0.25 per cent of the volume of the milk or 0.05% citric acid, until the mixture attained a TSS content of 65-70 per cent. The hot mixture is poured in sterile containers or lacquered tin cans and sealed hermetically. It gives a delicious instant drink, which is milk-white in colour when mixed with water and is also an excellent bread spread. It is used as a topping for bakery products or as a mixer in alcoholic drinks or may be diluted in water and used in cooking rice cakes and other delicacies.

Coconut jam

Coconut jam is a high-sugar coconut food product commonly consumed as dessert, bread-spread, etc. It is prepared by cooking sweetened coconut milk to a very thick consistency at low heat with constant stirring. Process for preparation of coconut jam using tender coconut pulp with a shelf life of 6 months has already been standardized. In the process developed in Philippines, coconut milk is extracted after mixing coconut gratings with equal quantity of water and mixed with brown sugar and glucose in the proportions of 10.25 percent and 5.5 percent respectively based on the weight of the milk, and cooked over a slow fire with constant stirring for about 20 minutes. The mixture is strained for removing suspended matter and again cooked over high heat. Before the mixture begins to thicken, citric acid at the rate of 0.25 percent of the original weight of the milk is added and cooking continued over low heat until the mixture thickens. The product is hot filled in sterilized containers and sealed hermetically. The jam so obtained has a rich creamy coconut flavor.

Coconut Syrup

A commercial product known as coconut syrup is produced from coconut milk, in Philippines. For this, coconut milk is first extracted from the freshly grated pared coconut meat. After homogenisation, an equal quantity of sugar and 0.05 per cent citric acid or 0.25 per cent sodium phosphate are added and then steam-cooked to a total soluble solid content of 65 to 68 percent. The boiling hot syrup is poured into lacquered tin cans, sealed and cooled under running water. The coconut syrup contains 27.18 per cent moisture, 3.11 per cent protein and 63.47 per cent total soluble solids. The syrup can be used for confectionery purposes. It gives a delicious instant drink, which is milk white in colour when mixed with water and is also an excellent bread spread.

Coconut honey

Coconut honey is viscous syrup, similar to coconut syrup but less creamy and less nutty in flavour used as topping for pancakes and waffles. To the coconut milk, 60% of brown sugar and 30% of glucose are added by weight with 0.5 per cent of sodium alginate as a stabilizer and then boiled in steam heated containers until a thick consistency is reached. The product is then hot filtered in lacquered sterile tin containers or bottles and sealed. The final product is a golden coloured, thick paste with a nut flavor. This can also be used as an excellent base for soft drinks. Coconut honey contains many growth promoting trace elements besides glucose, fructose and levulose.

Bottled coconut water

National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram has developed a process for the upgradation and preservation of mature coconut water. The main operation involves collection, upgradation, pasteurization, filtration and bottling. The process essentially consists of upgrading the flavour of mature coconut water to the level of tender coconut water by supplementation with additives including sugar and preserving it by a judicious combination of heat pasteurization and permitted chemicals.

Coconut water squash and Ready to serve

Coconut water squash and ready to serve can be prepared from mature coconut water using the ingredients sugar, citric acid, lemon juice, ginger and sodium benzoate. It contains sodium, potassium, Vitamin C and Carbohydrate with calorific value of 300 Kcal. The carbonated and non-carbonated beverages stored in aluminum and poly ethylene laminated packages has a shelf life of six months at room temperature.

Coconut Vinegar

Coconut vinegar is the resultant product of alcoholic and acetic fermentation of sugar enriched coconut water. Coconut water can be converted into vinegar by using vinegar generators. The matured coconut water consisting of about 3 per cent sugar content is concentrated to 15 per cent level by fortifying with sugar after filtration. Then, the sugar is heated to boiling point. The pasteurized mixture is then cooled and inoculated with active dry yeast Sacharomyces cerviseae (1.5g/Litre). After alcoholic fermentation for about 5 to 7 days, the clear liquid is siphoned off and inoculated with mother vinegar or starter culture containing aceteobactor bacteria. This acetified vinegar is then aged before bottling. The vinegar generator assembly comprises a feed vat, an acidifier and a receiving vat for collection of vinegar. Vinegar has extensive use as a preservative in the pickle industry and flavouring agent in food processing sector. It is rich in vitamins and minerals such as calcium, phosphorous, iron, sodium and also found to have anti inflammatory and anti microbial properties.

Specification

Acidity as acetic (g/100ml)	5.26 - 5.76
Total solids (%)	1.83 - 1.92
Total ash (%)	0.38 - 0.42
Sp. gravity	1.012 - 1.008
Alcohol	Nil

Techno economic details

Machineries required	Feed trough, vinegar acetifier ,receiving trough, wooden storage drums
Capacity	100 litres coconut water/ day
Yield	100 lites vinegar
Land	25 cents
Total Project Cost	Rs. 6 lakhs
Building (Area - 750 sq. ft.)	Rs. 3.0 lakhs
Plant & Machinery	Rs. 2.5 lakhs
Preliminary & pre-operative expenses	Rs. 0.25 lakhs
Contingencies	Rs. 0.20 lakhs
Margin money for working capital	Rs. 0.25 lakhs

Annual sales turnover	Rs. 4.0 lakhs
Net profit	Rs. 0.8 lakhs
Return on investment	20 per cent

Nata-de-Coco

Nata de coco is a translucent gelatinous product prepared from matured coconut water by the action of cellulose forming bacteria namely Acetobacter aceti subspecies xylinium. Acetobacter xylinum metabolizes glucose in coconut water that act as carbon source and converts it into extracellular cellulose as metabolites. The organism can be cultured either in coconut water or skimmed coconut milk. It is widely used in desserts and confectioneries especially in ice creams and fruit cocktails. It is much appreciated for its high dietary fiber, low fat and zero cholesterol content. Because of the high fiber content, it helps to clean human intestines and prevent constipation.

Coconut water is strained and mixed with sugar and glacial acetic acid in stipulated proportions (for every litre of coconut water, 100 g of refined sugar and 5 g of monobasic ammonium phosphate are added). It is then boiled for ten minutes and cooled. Then the Acetobacter xylinium culture solution (150 ml) along with glacial acetic acid (10 ml) of glacial acetic acid and 150 ml of starter or mother liquor containing A. xylinium were added and filled in glass trays or wide mouthed jars covered with a muslin cloth which is kept for 2-3 weeks without any disturbance. During this period, a white or cream colored jelly-like substance forms and floats on top of the culture medium. At this stage, the jelly-like substance or Nata would be about an inch thick. This surface growth is harvested, sliced into cubes, approximately 1x3 cm or according to requirement. Then, this is washed thoroughly to remove the acid taste smell. The nata is drained and the sugar equal to the weight of drained nata is added, thoroughly mixed and kept over night. The next day, the mixture is stirred to disperse any undissolved sugar. Small amount of water is added. The mixture is heated to the boiling point with occasional stirring. Any flavour material can alaso be added at this stage. The mixture is kept overnight and the heating process is repeated until the nata is fully penetrated with sugar as evident by the clear and crystalline appearance of the sweetened nata and preserved in either tin containers or bottles. Optimum temperature for nata production is in the range of 23-32°C.

The gelatinous growth is believed to be composed mainly of polysaccharides, probably dextrose and to be cellulose in nature. Nata-de-Coco is very delicious dessert item in the Philippines and other countries, particularly in the United States, which is served either mixed with other fruits or baked into a delicious cream pie or simply served with flavored syrup.

Techno economic analysis

Capacity	100 litres mature coconut/ day
Land required	5 cents
Building	Rs. 2 lakhs
Equipment/glasswares	Rs.0.5 lakhs

Yield	20 kg Nata-de-coco
Annual sales turnover @ Rs.40 / kg	Rs. 3.75 lakhs
Net profit	Rs. 1 lakh per annum
Return on investment	40%

Fig.2.24: Nata de coco

Tender coconut punch and cutter

Tender nut punch and cutter (Fig. 2.25.) is a simple device to pierce the six to seven months old nuts and to cut open it after drinking the water inside. The punch consists of a square base made of MS angle of 40 cm length. The tender nut is placed on the nut holder which is a circular and hollow in shape with a diameter of 10 cm. The tender nut can be placed on the nut holder and by operating the lever mechanism a hole of 12 mm diameter is made in just 4-5 seconds. A straw is put in the hole and one can drink the nut water. Tender Coconut Cutter consists of a wooden base of 50 cm length, a stand, a knife and a hand lever. The stand is mounted on the base. The cutting blade is mounted concentric to the stand and retained at a height of 15-20 cm. Tender coconut, after drinking the water, is placed on the wooden platform and cut open by pressing the lever attached to the blade. Using these machines 20 tender coconuts per hour could be served.

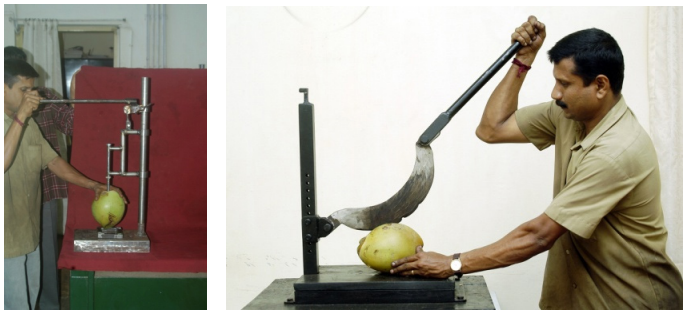


Fig. 2.25: Tender Coconut Handy Punch cum Splitter

The punching mechanism contains a 19 mm diameter stainless steel pipe with a profile at the end to pierce the tender coconut. To reduce the friction between inner tube and pierced tender coconut cork, tube entry diameter is reduced to some distance. The piercing tube is moved up and down using a manually operated lever. Tubular adjuster is provided at the base to the center of the punching pipe to accommodate the various sizes of tender coconut. The splitting is done using a stainless steel blade fitted with extended lever. The base of the splitting blade is placed at certain angle, to transfer the cutting load to the center of the frame. A stopper is provided perpendicular to the base frame to place the tender coconut in a balanced position.

(http://www.tradeindia.com/fp1296725/Tender-Coconut-Opener.html).

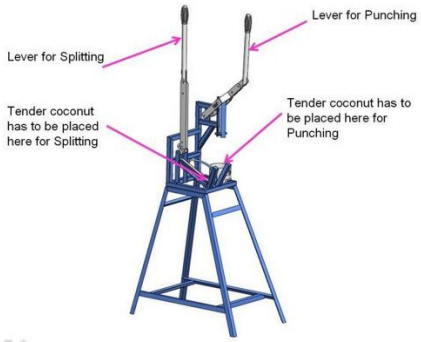


Fig. 2.26: Tender coconut handy punch cum splitter

Tender coconut punch cum splitter

The machine (fig. 2.26 and 2.27) has a container at the base which has two compartments, one to store tender coconuts and the other with bag holding hooks for storing consumed tender coconuts. On the top of the container, the punching and splitting mechanism is placed.

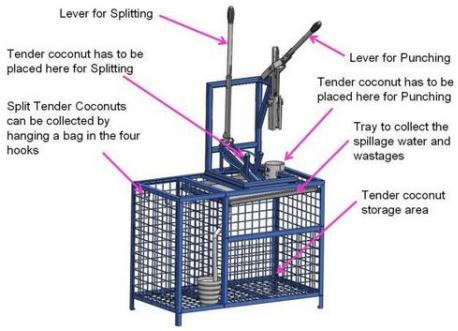
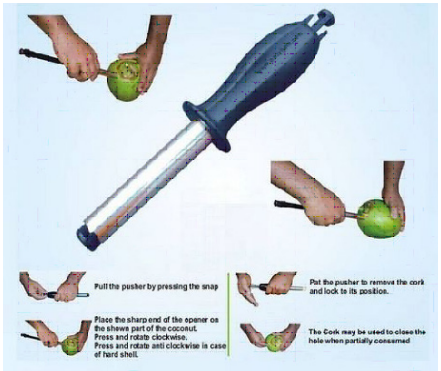


Fig.2.27: Tender coconut punch cum splitter

Tender coconut opener

The tender coconut opener is a tool designed to make a hole in top of the tender coconuts to drink the water. It was made from a 19mm diameter stainless steel tube which was moulded with an ergonomically designed plastic handle. The end of the stainless steel is having a cutting profile like a reversed saw tooth with sharp cutting edge along the periphery. In clockwise rotation, it will have smooth cutting edge which will cut the soft tender coconut fibers and not to pull the fibers. In anticlockwise rotation, it will cut the hard shell like a sharp saw tooth. The tender coconut opener is having a plastic moulded stem in the middle of the tube for pushing out the material inside the tube, after opening the tender coconut. In the top end of the stem, it has snap fit such that it will lock to safeguard the sharp cutting edge during accidental falling and avoid contact to the fingers when not in use (http://www.tradeindia.com/fp1296725/Tender-Coconut-Opener.html).



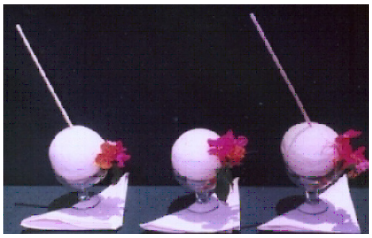
Minimal processing of tender coconut

Tender coconut is perishable as once the tender coconuts are detached from the bunches, its natural freshness will get lost within 24 to 36 hours even under refrigerated conditions unless treated scientifically. The bulkiness of tender coconut is due to the husk which accounts for two-third of the volume of tender nut. Technologies for minimal processing of tender coconut have been developed by Kerala Agricultural University (KAU) for retaining the flavour and to prevent discolouration. The process involves dipping (partially) dehusked tender coconut in a solution of 0.50% citric acid and 0.50% potassium metabisulphate for three minutes. The product (Fig. 2.28.) can be stored up to 24 days in refrigerated condition at 5-7°C. By using this process, tender coconut can be transported to distant place served chilled like any other soft drink. Optimized uniform size facilitates using of plastic crates and insulated chill boxes for transporting and storage. In Thailand, young coconuts are trimmed, treated (1-3% sodium metabisulphite) and packaged with opener, straw and spoon are commercially produced, marketed and exported. The shelf life of the processed young coconut is 45 days in 3-6°C or 3 weeks in 7 –10°C.

Fig. 2.28: Dressed tender nuts

Snow ball tender coconut

Snow ball tender nut is a tender coconut without husk, shell and testa which is ball shaped and white in colour. This white ball will contain tender coconut water, which can be consumed by just inserting a straw through the top white tender coconut kernel. Seven to eight month old nut is ideal for making Snow ball tender nut in which there is no decrease in quantity of tender nut water and the kernel is sufficiently soft. The technology for preparing snow ball tender nut (SBTN) has been developed at ICAR-CPCRI, Kasaragod. This is served in an ice cream cup. The user can drink the tender nut water by piercing the kernel with a straw. After drinking water, the kernel can be consumed using a fork. The coconut water is not exposed to the atmosphere and is natural and sterile



The machine consists of a circular blade having 24 teeth of 8 mm width that rotates at a speed of 1440 rpm. The prime mover of the machine is a 0.5 HP single phase electric motor. The prime mover attached with the circular blade is fixed on an angle iron frame with a covering made of mild steel sheet. A stop cutter box of stainless steel with a clearance of 15mm is used to cover the circular blade. The adjustable stop cutter box helps the user to control the depth of cut and protects the user from possible injury while operating the machine. A flexible knife known as scooping tool

also has been developed for scooping out the tender nut kernel from the shell. The scooping tool is made of nylon and is flexible at one end. The scooping tool is inserted in between the kernel and shell through the groove and is rotated slowly to detach the entire kernel from the shell.

Packaged tender coconut water

The Coconut Development Board (CDB) in collaboration with the Defence Food Research Laboratory (DFRL), Mysore has developed a technology for preservation and packing of tender coconut water in pouches and aluminum cans/ pouches (Fig. 2.29.) with a shelf life of three months under ambient conditions and six months under refrigerated conditions. Apart from that, a tetra pack technology has also been established in Tamil Nadu. The products are available in both domestic and international markets. Major exporters of the product are Philippines, Indonesia, Malaysia and Thailand.

The Defence Food Research Laboratory, Mysore under sponsored project of the Board has also developed technologies for mechanical cleaning of tender coconuts, mechanical chopping and collection of tender coconut water, additive treatment and mixing and filling of water into pouches/ cans, modification of process (hot filling) for PET bottles, conveyor system to carry pouches/cans to continuous pasteurization system. The technology is being adopted by the existing units for quality upgradation. FAO has also patented a technology for bottling tender coconut water using micro filtration technology.

Techno economic details

Machineries required	Mechanical washing system with conveyor, automatic boring and sucking system, ss filter / clarifier, collection tank, treatment tank, pasteurization unit, boiler, filling and sealing machine, shrink wrapping machine, air compressor, coding machine
Capacity	5000 coconuts / day
Total project cost	Rs.131.4 lakhs
Plant & Machinery cost	Rs.65 lakhs
Internal rate of return	18%
Breakeven point (sales)	51%

Fig. 2.29: Packaged tender coconut water

Fruit juice blended tender coconut water

Process for preparation of pomegranate, blue grapes, pineapple, mango and lemon juice blended tender coconut water beverage with a shelf life of six month sunder room temperature have been standardized by Central Food Technological Research Institute (CFTRI) under sponsored project of CDB.

Coconut water beverages

The processing technologies for coconut water beverages available are given below:

RRL technology: Regional Research Laboratory (RRL), Thiruvananthapuram/ National Institute for Interdisciplinary Science and Technology, Kerala has developed a process for the upgradation and preservation of tender and mature coconut water. The main operations involve collection, upgradation, pasteurization, filtration and bottling. The process essentially consists of upgrading the flavour of mature coconut water to the level of tender coconut water by supplementation with additives including sugar and preserving it by judicious combination of heat pasteurisation and permitted chemicals. The drink can be carbonated and marketed as beverage.

German technology: Spray evaporation Technique (SET) is adopted in this technology FOR MAKING fruit juice concentrate has been developed by M/s Winter Umwelttechnik, German. The product retains all the original characteristics of juice such as retention of vitamins and enzymes, aroma, colour, taste etc. This technique was first used for concentrating tender coconut water was by M/s Miracle Food Processors International (P) Ltd. Perinthalmanna, Kerala. The coconut water concentrates has a shelf life varying from 6 months to 24 months depending upon the degree of concentration. Ten liters of tender coconut water is required to make about 800g of concentrate. Aerated and bottled ready to drink coconut water beverage also can be made from coconut water concentrate.

Preserved tender coconut water

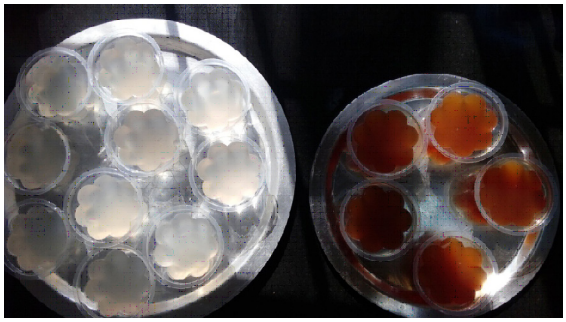
Preserved tender coconut water involves collection of water, filtration, adjustment of pH, total soluble sugar and taste, pasteurization, filtration and packaging. Ultra filtration system can also be used to clarify the tender coconut water. It can either be packed in bottles or in cartons. The bottled drink can be stored for three months at ambient temperature. A system for non thermal preservation of tender coconut water was developed using low ash filter paper and cellulose nitrate membrane which reduced the microbial population and retained the organoleptic properties. Since the tender coconut water is highly susceptible to heating, it is subjected to minimum heating and bio preservatives like Nisin is added, which helped in maintaining the natural pH of 4.9-5.2. The product has a shelf life of three months under ambient storage conditions.

Frozen coconut water

Fresh tender coconut water is collected under hygienic condition and suspended solids and oil

in the samples are removed by means of three-way centrifuge. The salts present in coconut water may be removed if desired, prior to concentration, to produce a very sweet product by centrifugation and passing the centrifuged coconut water through a mixed-bed ion-exchange resin. Ten litres of coconut water would yield about 800g of concentrate. The concentrate can be frozen or preserved in cans and after dilution to the desired strength; it can be used as base for the production of carbonated and non-carbonated coconut beverages. The concentrated coconut water is also reported to be used successfully in the brewery industry.

Tender coconut water jelly



Tender coconut water is a suitable option for the preparation of jelly as its delicate flavor can be well preserved in the form of jelly. The ingredients such as tender coconut water, sucrose and solidifying agent (china grass) are needed to prepare tendernut water jelly. The standardized quantity and concentration were tender coconut water 1L, sugar-150 g (15% of tender coconut water) and china grass- 10g (1% of tender coconut water).

Tender coconut water is heated in a sauce pan with sucrose and china grass. Care should be taken to continuously mix the content during heating with a stainless steel spoon/ ladle to melt the china grass in the tender nut water. Once it is completely melted, remove from the heat, cool it and pour in a wide mouth vessel/ tray and keep inside the refrigerator for about 3 hrs to solidify. Once after solidification, cut the pieces in cubes or squares and serve along with ice cream/ any other desserts as toppings.

Preservation ofTender Coconut Kernel

Tender coconut kernel is a good source of carbohydrate, fiber and other nutrients. Protein content was high in the eight months old fresh coconut meat. Products such as tuty-fruity, candy, preserve and chips can be prepared from the fresh kernels. The tender nut kernels are made into pieces, mixed with cane sugar and subsequently drained and dried are called candied fruits. Candied fruit covered with a thin transparent coating of sugar is called a glazed fruit. When candied fruit is coated with sugar or sugar crystals are allowed to deposit on it, it is called crystallized fruit.

Young coconut is washed and split open to remove the water. The soft kernel is scooped out and cut into cubes. Pricking should be done with stainless steel forks. In the case of crystallized candy, after pricking, immerse the fruit pieces in dilute limewater (1.5 %) or alum (2 %) for few minutes before further processing. The pieces are washed 3-4 times with fresh water and blanched for 5 minutes in boiling water to make them soft. This assists in absorption of sugar and prevents enzymatic browning. Sugar (50 %) was spread on the blanched fruit pieces in alternative layers.

Syrup is drained on next day and enough sugar is added to raise the concentration of the syrup to about 60°Brix. Citric acid is added as preservative. Coconut pieces are added, boiled and kept for 24 hours. The process is repeated every day until the Brix of residual syrup reaches 70-75°. The syrup is drained and pieces are dried in hot air and stored in glass bottles/polyethylene bags. In the case of crystallized candy, the concentrates of sugar syrup is continued till Brix value reaches 70-78°. Syrup is drained off and the pieces are rolled in finely ground sugar. Crystallized candy can be stored for 3 months.

Canning of Tender Kernel

For canning, kernel from 8-10 months old nuts is first scooped out, the adhering testa removed by using a sharp knife and the pared meat cut into stripes of 0.5 cm thick and 6 cm long after washing. The stripes are put in cans to which is added 50° B syrup with 0.01 per cent sodium metabisulphite. The filled cans are then exhausted at 78°C, sealed and processed at 110°C for about 20 minutes. A jelly like meat formed during the process is scraped out and to every part of the meat, a corresponding amount of refined sugar is added. The mixture is cooked in low heat until the sugar is totally dissolved, hot packed in sterilized bottles and closed tightly.

Tender Coconut Jam

Tender coconut jam is an intermediate moisture food prepared from the residual pulp left after removal of water from the kernels. It is a high-sugar coconut food product with light to dark brown in color, thick spreadable in consistency, with a rich creamy flavor. Coconut jam is prepared by boiling the pulp with sugar, pectin, acid, and other minor ingredients such as preservatives, coloring, and flavoring materials, to a reasonably thick consistency. The desired amount of sugar was added to the pulp mixture and heated continuously on under low flame. When the total soluble solids reached 60 °Brix, pectin (1.25 %) and citric acid (0.5 %) were added to the boiling pulp and the mixture was stirred continuously using a steel ladle. Heating can be stopped when the total soluble solids reached 67–68 °Brix. The hot mixture was filled into sterilized glass bottles and cooled under ambient conditions. The prepared jam can be stored for a period of 6 months at ambient temperature without compromising the quality. Chauhan et al. (2013) studied the organoleptic properties and shelf stability of mixed fruit jam using tender coconut pulp and pineapple pulp in different ratios. It was found that the combination of tender coconut pulp and pineapple pulp in the ratio of 75:25 resulted in a jam with good organoleptic and textural characteristics. Jam also could be developed in combination with pine apple pulp and guava pulp with tender coconut pulp with an objective of increased palatability and sensory acceptability.

Coconut Pulp Ice Cream

Tender coconut pulp can be used in ice cream formulation to replace milk, fat, gums and emulsifier, common ingredients in this kind of food. The product would be milk free, no lactose, low fat and no cholesterol food. The formulations included the following ingredients: coconut pulp, cocoa powder, sucrose, water, carrageenan gum, guar gum and hydrogenated vegetable fat. The liquid ingredients and the pulp were blended and heated in a tank until the temperature reached 45-50 °C, when the powdered ingredients were added. Then the mix was pasteurized at 87 °C for two minutes. After 24 hour of ageing, the freezing-whipping step was accomplished using shaved surface heat exchanger. Finally, the product was kept at -5 °C to complete the freezing stage and stored at -18 °C. The most satisfactory product contained 41% coconut pulp, 11% cocoa, 17% sucrose and 31% water. The product contained 65% water, 1.0% fat, 2.4% protein, 0.36% ash and 31.2% carbohydrate

Tender nut pudding

Pudding is a common dessert food or a savory dish commonly served in parties and functions after the heavy meal. Tender coconut pulp and water can be included as an ingredient in the pudding. The recipe for the tender nut pudding devoid of dairy milk and non vegetarian based gelling agents followed in ICAR-CPCRI contains coconut milk (100 ml), coconut sugar (15 g), china grass (1%), tender coconut water (200 ml) and tender coconut pulp (50 g).

Initially the china grass is mixed in the tender coconut water in a sauce pan and heat it till it completely melts in coconut water. Then add coconut milk and coconut sugar into it. Heat the content for 15 min. Then take the pan from the heat and immediately pour in a pudding dish or a tray. Add tender nut pulp (preferably cut in the form of small cubes) into the pudding mixture. Then keep it inside the refrigerator. The maximum time required for complete setting of the tender nut pudding is 1 hr.

Tender coconut water lemonade

Any sweetened beverage characterized by lemon flavor is known as Lemonade. Coconut water lemonade is a refreshing drink made of tender coconut water and lemon juice with addition of flavor ingredients. The product contain tender coconut water (500 ml), tender coconut pieces-100 g (1 cm3), lemon juice (15 ml), ginger juice (2 ml), pepper powder (0.5 g) and coconut sugar (10 g).

Cut open the tender nut, collect the water and scrap the pulp and cut into uniform sized cubes. Keep the tender nut water in a jar. Add lemon juice, ginger juice, pepper powder, and sugar and mix well with a hand mixer at a low speed for 2 min. add the tender nut cubes into the lemonade and serve under chilled condition

Tender nut phirni

Phirni is nothing but a rice pudding. The recipe of coconut based phirni includes tender nut water (100 ml), tender nut pulp (50 g), coconut milk (100 ml), rice powder (10 g), coconut sugar (40

g) and cardamom (crushed/ powdered) (0.5 g). Mix the rice powder and tender coconut water. Ensure that there is no lump formation in the mix. Then transfer it into a sauce pan or kadai and heat with continuo stirring. Grind the tender nut in a mixer grinder to a coarse texture so that the bite should be felt while consuming the final product. When the rice powder- coconut milk mix comes to boil, add the grinded tender nut pulp, coconut milk and coconut sugar. Continue stirring till it gets a thicker consistency. Add the crushed cardamom. Transfer the coconut based phirni from the pan to a serving bowl and serve chill with addition of dry fruits (optional).

Medium/low fat, desiccated coconut flour

After extraction of milk, the residual coconut cake can be dried and sold as medium/low fat, desiccated coconut, which may be used in bakery and preparation of low calorie foods. It is a unique product prepared from coconut residue. Coconut flour, also called as 'sapal', a by-product in the processing of coconut milk, can provide not only value-added income to the entrepreneurs but also a nutritious and a healthy source of dietary fiber for the consumers. It can be used as fillers, bulking agents and substitute for wheat flour, rice flour and potato flour at certain levels and incorporated into various food products like baked products, snack foods, steamed and extruded products. The dried coconut residue is passed through a special type of screw press under a specified expeller setting to reduce oil content of the residue. The defatted flakes are dried to reduce its moisture content to 2.5 to 3.0 per cent. The product has a low content of fat and higher percentages of protein, sugars and minerals and has been found to possess better water holding and thickening properties. Flour derived after removing 60 percent oil has been found to have higher consumer acceptability.

These flakes can also be utilized in different food formulations such as extrusion, baking and confectionery. They can also be used for enriching the nutritional values of wheat flour, rice flour etc. The oil extracted from the dried gratings is of superior quality, which could command premium price. Coconut flour is naturally low in digestible carbohydrates and high in fibre content and good proteins and hence is a health promoting food. This has 4 times more fibre than oat bran, 2 times more than wheat bran. Technologies are available now to prepare coconut milk residue and virgin coconut oil (VCO) cake flour based compressed bar, porridge, laddoo, halwa, and noodles. Processes for preparation of extrudates, pasta, muffin cakes and ready-to-eat food items such as coconut pickle and coconut chutney powder have been developed and standardized by ICAR-CPCRI, Kasaragod. These products can be prepared from the by-products obtained while preparing the coconut milk, coconut milk powder and virgin coconut oil. It may have some health benefits and may encourage the industry to produce value added products or functional foods which can help in the proper control and management of chronic diseases. This offers scope for utilization of coconut flour as a dietary component for diabetes. Low-fat, high fibre coconut flour, a unique product from 'sapal' is a good source of dietary fibre. It is comparable with other cereal

flours in terms of carbohydrate, fat, energy content and is a good ingredient in nutraceuticals.

The Central Food Technological Research Institute (CFTRI), Mysore, India has developed a process for the manufacture of edible flour. Here the wet kernel is first separated from the shell by crushing the cups in a hand operated gadget. After removing the shell pieces by hand, the kernel is pared, washed free of dirt, passed through a pin type disintegrator and gratings sieved. The gratings are then dried in less than 30 minutes in a cross flow drier to less than three per cent moisture. Oil is partially extracted from these gratings using a hydraulic press in 10 kg batches. This oil possesses better quality than commercial samples and the residual product is white and powdery with good flavour. The composition of the flour is given in Table 2.4.

Table 2.4: Composition of coconut flour and desiccated coconut (in percentage)

Constituent	Coconut flour	Desiccated coconut
Moisture	3.83	1.70
Fat	41.43	70.05
Protein	17.32	8.30
Crude fibre	7.00	4.65
Ash	3.26	1.62
Total carbohydrates	27.16	13.69

The Regional Research Laboratory (RRL), Trivandrum, India also perfected the technology for the partial extraction of oil from desiccated coconut in order to produce, besides oil, good quality coconut flour. Here the pared kernel pieces are first washed and soaked in hot water at 80°C for 10 to 15 minutes to reduce the microbial load and also to inactivate enzymes. Here also, the kernel pieces are comminuted into fine gratings using a pin mill and dried at 60 °C - 70°C. The dried gratings are charged into a perforated stainless steel cage and pressure is applied from the top using a down stroke hydraulic press till the desired level of oil has been expelled. The oil is stored for 10-12 hours and filtered using a filter press in the presence of 0.1 per cent super cell as filter aid. The partially defatted gratings are removed and powdered using a cake-breaker and further dried in an electric drier to a moisture content of two to three per cent. The fat content of the final flour is adjusted to 40-45 per cent. The shelf-life of the product stored in sealed aluminium foil pouches is four to six months at ambient temperature and more than one year under refrigerated conditions. About 12-15 per cent of the fresh meat constitutes a by-product, with an oil content of 60 per cent on dry weight basis. About 90 per cent of this could be recovered as commercial grade coconut oil.

The product has a low content of fat and higher percentages of protein, sugars and minerals and has been found to possess better water holding and thickening properties. The oil extracted from the dried gratings is of superior quality, which could command premium price. Flour derived after removing 60 per cent oil has been found to have higher consumer acceptability. The proximate composition of flour from pared and unpared coconut as reported from different sources is given in Table 2.5. It is also seen that five percent coconut flour can replace proportionate amounts of wheat flour and non-fat dry milk powder used in school nutrition programmes without affecting baking qualities and food value.

Table 2.5: Proximate composition of coconut flour (in percentage)

Constituent	From pared coconut *	From unpared coconut **
Moisture	5.69	5.4
Fat	7.18	2.0
Crude fibre	9.21	9.8
Protein	20.39	24.9
Ash	5.41	5.3
Carbohydrates	—	62.4

Nutritionally coconut flour compares favorably with most of the common cereal flours as could be seen from Table 2.6.

Table 2.6: Nutrient composition of coconut flour compared with various seed flours (in percentage)

Nutrient	Soybean	Ground nut	Sesame	Cotton seed	Coconut	
Moisture	5.00	11.00	5.60	9.20	11.20	5.40
Protein (Nx6.25)	60.00	52.00	33.30	51.10	20.90	24.90
Fat	7.00	8.90	12.20	5.50	13.30	2.00
Carbohydrate	30.00	21.80	38.10	25.80	39.20	52.60
Crude fibre	2.50	1.00	4.80	1.50	10.50	9.80
Ash	5.50	4.60	6.00	5.90	4.90	5.30
Calcium	0.33	0.67	2.38	0.36	0.16	0.07
Phosphorous	0.62	0.50	0.63	0.82	0.49	0.47
Iron	20.00	2.90	19.30	12.00	5.70	8.10
Thiamine	0.7	0.95	1.05	0.99	0.17	0.09
Niacin	5.70	19.50	5.30	5.20	4.10	2.30
Riboflavin	0.38	0.20	0.3	0.30	—	0.08

Dietary fibre from coconut residue

The importance of dietary fibre in the human diet is gaining more attention due to the increasing awareness of its beneficial effect. The CFTRI, Mysore has carried out a study to develop a natural laxative based on dietary fibre from coconut residue. The study proved that water retention capacity, water holding capacity and swelling capacity of coconut fibre is comparable with other commercially available dietary fibres.

Coconut protein powder

Coconut protein powder can be recovered from coconut wet processing waste which is obtained during the production of virgin coconut oil. The coconut milk from fresh and mature coconut undergoes protease treatment (100 tyrosine units/liter of coconut milk) for 2 h in order to carry out effective destabilization of the coconut milk emulsion. Enzyme-treated milk is subjected to centrifugation at 7,000 rpm to obtain cream, coconut skim milk, and solid protein. Further, skim

milk and solid protein is thoroughly mixed in the ratio of 8:2 v/w, homogenized and fed into a spray dryer. Then the protein powder is collected through a cyclone separator. The coconut protein powder showed high protein content of about 33 % and low fat content of 3 %. The protein powder had good emulsifying properties than skim milk protein and also had more water retention and swelling capacity than other dietary fibers.

Coconut inflorescence sap / Neera / Kalparasa

Coconut phloem sap popularly known as neera is a natural health drink traditionally collected from the coconut spadix rich in sugars, protein, minerals, antioxidants, vitamins, etc., utilized by the plant for the growth and development of tender or mature coconut. As the flow of sap is slow and highly prone to fermentation, collection of unfermented sap is a challenging task and that has been resolved with the development of CPCRI developed 'Coco sap chiller'. The sap collected by coco-sap chilller at low temperature is observed to be entirely different from the neera collected by traditional method with or without preservatives; hence it was christened as "Kalparasa". Sap collected using the coco-sap chiller is golden brown in color, delicious and free from contaminants like insects, ants, and pollen and dust particles.

Coco-sap chiller (Fig. 2.30) is a portable device characterized by a hollow PVC pipe of which one end is expanded into a box shape to house a sap collection container bound by ice cubes and the other end is wide enough to insert and remove a collection container of 2 to 3 litres capacity. Each side walls of the pipe from outside are covered with an insulating jacket excluding the portion of spadix holder which retains the internal cool temperature for a longer period. This coco-sap chiller is lighter in weight, water proof, easy to connect to the spadix, requires less ice, and retains low temperature for longer period as compared to commercially available ice boxes.

Fig.2.30: Coco sap chiller

Coco-sap chillerKalparasa collected by coco-sap chiller under low temperature meets the Codex Alimentarius (International Food Standards WHO/FAO) definition of juice as "unfermented but fermentable juice, intended for direct consumption, obtained by the mechanical process from extractable fluid contents of cells or tissues, preserved exclusively by physical means". Thus it is amenable to be sold as fresh juice under local market with the adherence to quality standards prescribed by CPCRI. It does not require lot of machineries but requires cold chain or refrigerated system

Quality standards

CPCRI has developed simple quality standards to check the quality of sap. pH of the sap can be easily measured by hand held commercial pH meters. Fresh sap has anything above 7 to 7.5 pH. Depending on the pH sap can be used for different purposes.

pH > 7 ideal for promotion to health drink

pH>6.5 Good for preparation of sugar

pH> 6.0 Can be used for jaggary

pH> 5.5 for concentrate.

Below pH 5.5 is not good for the above value added products but can be used for the preparation of vinegar. Other quality parameters easily judged are brix around 14; color golden brown; and taste sweet and delicious.

Quality attributes of sap

Distinct differences are noticed between the sap collected by traditional method and CPCRI technique (Table 2.7.) Fresh sap collected by CPCRI technique is slightly alkaline in pH, golden brown or honey colour, sweet and delicious.

Table 2.7: Quality attributes of sap collected by CPCRI technique and traditional technique

Attribute	CPCRI Technique	Traditional technique
Soluble solids (°Brix)	15.5 to 18	13 to 14
pH	7 to 8	6 or low
Colour	Golden brown or honey	Oyster white
Defects, decay, insects, pollen, dust	Absent	Present
Flavour	Sweet and delicious	Harsh odour
Pathogens, chemicals and extraneous		
matter	Absent	Present
Microbial load	Low	High

Storage: The collected sap can be stored for any length of time under subs zero temperature. Deep freezers are used for the purpose. The sap gets freezed and just before use it is thawed to get the original liquid form. However, under refrigerators the quality gets deteriorated within few hours.

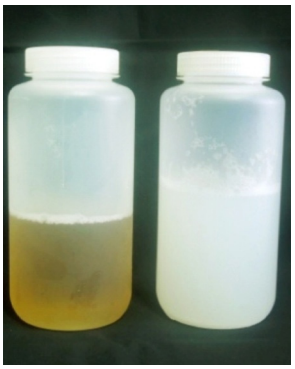


Fig.2.31: Coconut sap collected by coco-sap chiller (left) and traditional method (right)

Techno economic details

Machineries/ devices required	Tapping gear (knives, tapping stick, scissor, mallet etc), o-sap chillers, neera collection ice box, ice carrying box, ph meter, measurement jug, neera storage container, neera transport box, freezer, neera dispenser etc.

Capacity	1000 liter of sap per day
Capital investment	Rs. 35,10,200
Operational cost per month	Rs. 75,875
Total cost of production	Rs. 1,06,91,785
Total sap production (l)	Rs. 3,65,000
Selling cost	Rs. 50/ l
Unit cost of production	Rs. 29/l
Breakeven period	Rs. 176
Net profit %	Rs. 41.41

Coconut Sugar

The hygienic, zero alcoholic sap collected by CPCRI method is easy to process in a natural way without the use of chemicals into various value added products which fetches premium prices both in domestic and international markets. Very good quality coconut sugar, jaggery, nectar or syrup can be produced in double jacketed cookers with temperature regulation and stirring facility.

Coconut sugar is the best natural sweetner also has several health benefits and thus has a high market potential. It contains all essential amino acids required for protein synthesis; contains considerable amount of minerals like calcium, magnesium, zinc, iron and copper; rich in electrolytes like sodium and potassium; abundant in dietary fibers which normalizes bowel movements and digestion; rich source of phenolics which are potent and important contributors in reducing oxidative stress due to their antioxidant activity. Moreover its glycemic index (GI) is low and is in the range of 35 to 54 GI/ serving and eating a low glycemic index diet reduces the risk of chronic diseases such as Type 2 diabetes.

Fig.2.32: Coconut sugar and Jaggery

Techno economic details

Labour cost	Rs. 5,04,000
Total fixed cost	Rs. 20,19,975
Total variable cost	Rs. 1,01,72,500
Total cost of production	Rs. 1,21,92,475
Total sugar production (kg)	Rs. 54,750
Selling cost	Rs. 275/kg
Unit cost of production	Rs. 223

Breakeven period	Rs. 150
Net profit %	20

Kalpa Bar

It is a coconut sugar based chocolate purely from plant based ingredients without milk is prepared. It is a joint venture between ICAR-CPCRI and CAMPCO (Central Arecanut and Cocoa Marketing and Processing Cooperative Ltd.). It contained cocoa powder, coconut sugar, natural vanilla extract and GMO free sunflower lecithin. It is low in glycemic index. It does not contain any added artificial ingredients. It is delicious dark chocolate for a healthy life and can be stored under room temperature and does not melt. It is available in 30 g slabs.

Fig.2.33: Kalpa Bar Dark chocolate from coconut sugar

Kalpa Drinking Chocolate

It is an instantised blend of low GI coconut sugar, crafted from fine cocoa powder formulated to produce the delicious drinking chocolate. It is to titillate the taste buds of drinking chocolate lovers who want a healthier life style. It does not contain any artificial ingredients. The product is produced by a unique technology of instantisation and agglomeration technique that makes the product soluble instantly in hot or cold milk releasing the chocolate aroma. The product is filled in 200g PET jars duly sealed, case corrugated.

Fig.2.34: Kalpa Drinking Chocolate

Methodology for the preparation of fresh coconut inflorescence sap (Kalparasa) based milk sweets have been standardized at West Bengal. The advantage is, it is another way of transporting neera to long distance in the form of sweets. These sweets impart the minerals, vitamins, valuable fiber which will not be available in the normal cane sugar based milk sweets and their glycemic index is low and hence good for healthy life.


Fig.2.33: Kalpa Bar Dark chocolate from coconut sugar

Diabetic friendly cookies

Diabetic friendly cookies are made with whole wheat, desiccated coconut or grated coconut and neera jaggery. Different types of cookies are possible with varied main contents like oats, multigrain, arrow root, corn, whole wheat and spices. Cookies made with neera jaggery is fit for this purpose since its glycemic index is very low (GI 35).

Ingredients

1. Wheat flour - 5.00kg
2. Butter - 3.25kg
3. Jaggery (Powdered) - 5.00kg
4. Grated coconut/Desiccated coconut powder - 1.87kg
5. Baking powder - 0.200kg
6. Vanilla essence - 0.100kg
7. Salt – Adequate

Nutritional Information

Carbohydrate (%)	38.85
Protein (%)	6.86
Fat (%)	40.90
Minerals (%)	0.28
Fibre (%)	2.51
Techno economic details	
Machineries required	40 kg of cookies(2700 cookies) per shift
Cost of ingredients/cookie	Rs. 3.55/-
Selling price of cookies	Rs. 85/ packet of 7 cookies
Land	10 cents
Building (2000 sq. feet @ Rs. 1000/sq. feet)	20 Lakhs
Other civil works (internal roads, compound wall, water tanks+ neera jaggery making unit)	Rs. 2 Lakhs
Machinery and Equipment	Rs. 13.49 Lakhs
Electrification	Rs. 0.50 Lakhs
Preliminary & Pre-op Expenses	Rs. 1.11
Working Capital margin	Rs. 0.90
Net profit after tax on Sales	Rs. 17.20 %
Pay Back Period	3 yr 10 months
Selling Price	Rs. 85 per pouch
Break Even Point (sales)	60.96%

Kalpa Krunch

Kalpa Krunch is a coconut milk residue enriched ready to eat extruded snacks. It is prepared from 60% rice flour, 25% corn flour and 15% coconut milk residue flour. It is coated with natural and healthy flavours. The flavours are formulated from ten different types of spices and vegetables including coriander, garlic, turmeric, clove, cinnamon, chilli, mint, cardamom, tomato and celery. Kalpa Krunch is rich in dietary fiber, protein, fat and carbohydrate with antioxidant activity. The steps involved in extrusion process are mixing, extrusion (140°C extrusion temperature and 220

rpm screw speed), drying (130°C for 20 min), flavour coating and packaging. The torque should be maintained around 12-14 for uniform and high expansion ratio.

The ratios of CMR, corn, and rice flour were 15:25:60. All the raw materials were mixed in a laboratory mixer (Basic Technology Pvt. Ltd., India) for 15 min. The initial moisture content of blend was determined using infrared moisture analyzer. Hence, before extrusion, calculated amount of water sprayed onto the flour blend to achieve the required moisture content of 14% and blend again for 10 min.

The prepared homogenous blends were extruded in a co-rotating twin screw extruder (Basic Technology Private Ltd, Kolkata, India). An extruder dies with a diameter of 3 mm was used for all trials. The screw speed and barrel temperature of the last zone was 220 rpm and 140 °C. Extrudates were collected after 5 min of steady state processing and dried in a coating machine (M/s Pharma Fab Industries, Mumbai, India) at 130 °C for 20 min. The dried extrudates can coat with different flavours. The oil should be sprayed before coating of flavours.

Techno economic details

Cost of Machinery	Rs. 44,00,000
Working capital	RS.47,80,000
Selling cost	Rs. 5 / packet
Unit cost of production	Rs.3
Breakeven period	Rs. 131.9
Net profit %	21

Fig.2.36: Kalpa krunch

VCO cake based muffins

Muffin is a sweet baked product appreciated among the consumers of all age groups, especially children due to its good taste and soft texture. The ingredients of muffins such as refined wheat flour, sugar, fat, and egg play an important role in the structure, appearance, and eating quality of the final product.

Muffin batter formulations were made by progressively replacing the refined wheat flour with VCO cake. The optimized formulation consisted of refined wheat flour (26g/100g) which was replaced with 40% VCO cake flour, sugar (26g/100g), egg (21g/100g), full fat milk (13g/100g), shortening (12g/100g), sodium bicarbonate (1.1g/100 g) and salt (0.1g/100g). Effect of the cake on physical, textural, microbial and sensory attributes of muffin was evaluated and found superior

in all the parameters. Moreover, the texture of the muffin became softer with the addition of VCO cake. 40g VCO cake/100g flour blend based muffin was enriched with protein (8.49%), fat (18.46%), crude fibre (1.14%) and minerals (1.15%).

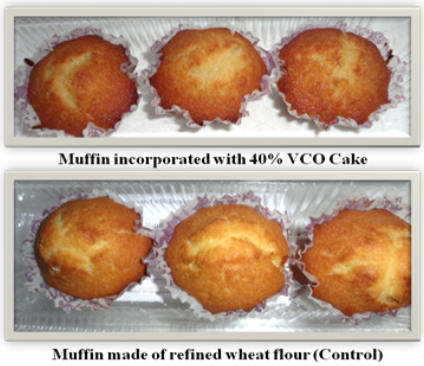


Fig.2.37: VCO cake based muffins

Virgin coconut oil

It is the oil obtained from fresh, mature kernel by mechanical or natural means, with or without use of heat and no chemical refining, bleaching or de odorizing. It is called "virgin" because the oil obtained is pure, raw and pristine. It has a fresh coconut aroma ranging from mild to intense depending on extraction process. It is extracted directly from the fresh coconut meat or from coconut milk or from coconut milk residue. The different methods involved are hot-processing, natural fermentation, centrifugation process and direct micro expelling method. The choice of the technology to be adopted depends to a great extent on the scale of operation, the degree of mechanization, the amount of investment available and the market demand. It is estimated that, after producing 4200 kg of hot process virgin coconut oil, the no profit no loss point will occur which will correspond to a respective sales volume of Rs. 33.5 lakhs and this respective stage will arrive after 168 days of functioning of the unit. Therefore the VCO making unit will start earning profit from sixth month after installation.

ICAR-CPCRI has developed processing technologies for production of VCO by hot and fermentation method. In hot process, coconut milk is cooked in specially designed cooker whereas in fermentation process, coconut milk is allowed to ferment in a specially designed fermentation tank for specified period to get VCO. The process protocol is given below,

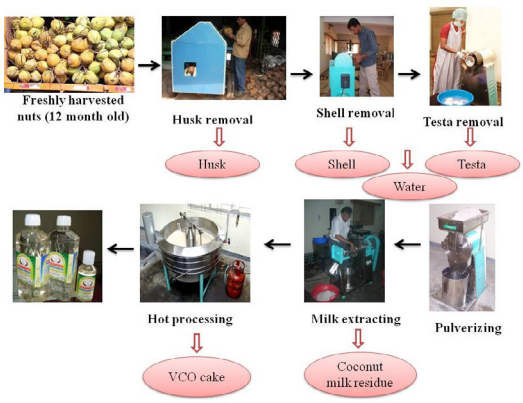


Fig.2.38: Flow chart of VCO processing

Table 2.8: Comparative quality characteristics of VCO by hot and fermentation processes with commercial coconut oil

Chemical parameters	Hot process VCO	Fermented VCO	Commercial Coconut Oil
Tocopherol (µg/g) (Vitamin E)	15-20	20-30	2-6
Polyphenols (µg/g)	500-700	350-500	150-250
Antioxidant activity (%)	80-90	65-75	35-45

Techno economic details

Machineries required	Coconut dehusker, Coconut desheller, Coconut testa removing machine, Coconut pulverizer, Milk expeller, VCO cooker, Vacuum dryer, Packaging system, Weighing Balance, Miscellaneous items such as stainless steel containers, stainless steel containers with trolley attached and other vessels, electrical fittings, electrical water heaters etc
Total investment on machines for processing 500 nuts /day	Rs.15 lakhs (Hot process
Rs.12 lakhs (Fermentation process)	
Unit Production Cost	Rs.420 per litre
Breakeven Period	103 days
Net profit percentage	47.17%
Production Details per year	VCO – 7500 litres (20% of kernel weight)
Milk residue – 7500 kg	
VCO Cake – 1500 kg	
Testa – 1000 kg	
Husk – 60000 kg	
Shell – 20000 kg	
Water – 15000 litres	

VCO based Margarine

Technology for preparation of virgin coconut oil based margarine to be operated at small and micro level industries is reported to be patented by Indonesia. The process involves mixing of emulsifiers, stearine, antioxidants, β-Carotene, water & salt with VCO, blending at 600C for 10 minutes, filling, packing and cooling at 160C. The product can be used as bread spread. It contains high lauric acids and no trans-fats.

VCO based mayonnaise

Mayonnaise is a semi solid food product mixed into fresh vegetables or fruits or cooked meat to enrich flavour. It is prepared by mixing coconut oil, vinegar or citric acid or emulsifiers. Carbohydrates, spices and flavour enhances are added to modify

the flavour and avoid crystallization. The final formulation would consist of 70% VCO, 6% natural vinegar, 7% fresh yolk and 1% emulsifiers and cooled boiled water. Mayonnaise production units can be commercially operated at home or micro level to enhance the income of farmer families.

Coconut chips

Coconut chips are a ready-to-eat, snowy white crisp and healthy non fried snack prepared from 8 to 9 month old fresh kernel through osmotic dehydration in a forced hot air electrical dryer at 70-80°C for 5-6 h to less than 3% moisture content. The kernels undergo paring, blanching, slicing and osmotic dehydration to prepare ready to eat chips. It contains 46% carbohydrate, 1.24% protein, 48% healthy fat, 6.13% fibre and 1.36% mineral content. Frying is not undertaken in coconut chips making process. Using the method of drying on the basis of osmosis, in which partial dehydration in sliced form is brought about by dipping the fresh kernel in sugar solution followed by hot air drying. This is claimed to result in product with better flavour than freeze drying method at comparatively lesser cost. Hence, the resultant coconut chips give health promoting substances and do not pose any health hazard. Nutraceutical and medicated coconut chips can also be made by incorporating juice of beet root, carrot, ginger and pepper.

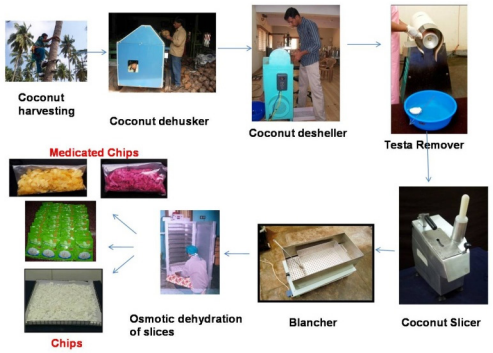


Fig.2.39: Process protocol developed for the production of coconut chips

Fresh kernel of 8-9 months old coconut is to be used for this purpose. Here the index for selection of the nut is that the nut should be matured enough to be sliced. If it is too tender, slicing and testa removing is not possible. Important steps involved in the production of coconut chips is given below,

Techno economic details

Machineries required	Coconut dehusker, coconut desheller, coconut testa removing machine, multi commodity coconut slicer, blanching unit, plastic basin, Filter, muslin cloth, vessel, gas stove Stirrer, Solar dryer, electric dryer, heat sealing machine etc.
Capacity	250 coconuts per day
Total investment on machines	Rs.6 Lakhs
Unit Production cost	Rs.8.45 / packet of 25 g
Breakeven Period	56 days
Net profit percentage	57.71
Production Details per year	
	Chips – 11250 kg
	Husk – 30000 kg
	Shell – 10000 kg
	Testa – 500 kg
	Water – 7500 litres

Fig.2.40: Coconut chips

Frozen coconut delicacy

Coconut milk can be the best substitute for dairy milk for those in the Asian countries especially in India where coconut is abundant and an integral part of the daily diet. Refined sugar, one of the most important ingredients of ice cream, imparts sweet taste, enhance the flavour, and affect its body and melting behaviour. However, its high calories and Glycemic Index (GI) leading to limitation for consumers concerned with health or suffer from diabetes and obesity. In this context, coconut sugar is a perfect alternative for refined sugar because of its low GI and high vitamins and mineral content. ICAR-CPCRI has made an effort to standardize a technology for coconut based frozen delicacy which is a vegan alternative for ice cream. The delicacy is made completely from coconut, with ingredients such as coconut milk, coconut sugar, tender coconut water and pulp. It's a premium product which is completely natural and healthy. It is enriched with vitamins, minerals &healthy fatty acids. Here the fat content of coconut milk is reduced to 10-11% (maximum). The methodology followed were, mixing, pasteurization, homogenization ageing, freezing and hardening. There is another variant in which dairy milk is replaced with standardized coconut milk along with other ingredients used in ice cream. The product has a total fat content of 11%.

Activated carbon

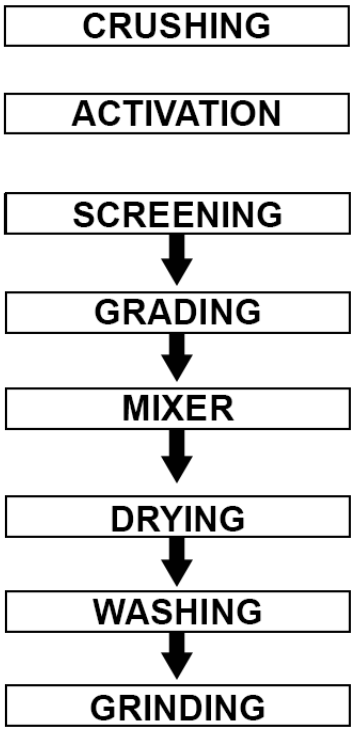
Coconut shell charcoal is a material with a very limited surface area. The absorption capacity for gases and colouring matter is, therefore very less. This can be increased by activation with chemicals. On with the ability to absorb effectively even trace quantities of either unwanted or valuable liquids or gases. Activated carbon plays a very important role in solvent recovery processes, water and effluent treatment, and in treatment of flue gas before discharge into the atmosphere.

In the activation process, shell charcoal is fed continuously into a retort. The normal activation process involves the use of steam at selected temperature for the selective oxidation of material, resulting in production of carbon with pores of molecular dimension. Shell carbon, having a cellulose base, produces material with a finer pore structure than obtained from coals. Approximately three tonnes of shell charcoal is needed to produce one tonne of activated carbon. Retorts designed to produce activated carbon usually operate in one of the three ways-vertically, horizontally, or by

means of a series of hearths. In a vertical retort, utilizing steam, activation is controlled by the rate at which the material is withdrawn from the discharge hopper. Activation can be carried out with a variety of gases, including oxides of carbon, chlorine, and mixtures of steam and air. After withdrawal from the retorts, the material is cooled and passed through a series of granulators and screens, thereby attaining carbon of a known quality, available in variety of grade sizes to suit many applications.

For certain specific purpose, different process is used to prepare the activated carbon. This process consists of the treatment of crushed coconut shells with surface active chemicals followed by drying and subjecting the material to carbonization. The carbonized material is activated with steam followed by air to facilitate oxidation.

The activated material is subjected to steam quenching to reduce the bed temperature and is then discharged in a receptacle. The material is subsequently subjected to acid treatment to adjust the pH value. The acid treated activated material is then washed with water, dried and stored. Granular activated carbon produced from shell charcoal is an important industrial material, and the prospects for the intermediate charcoal appear to be good as long as quality is maintained. In general, activated carbon is used where the compound to be absorbed has a small molecular diameter or, if it is a gas, when a boiling point is below 100°C. The use of this type of carbon is also specially indicated where the concentration of the absorbate is very low. While the shell based activated carbon is considered superior to those obtained from other sources because it is generally dense, very hard, and highly retentive. They have a very fine pore structure, and their rate of absorption is generally faster than coal carbons.



Coconut Husk

Coconut husk is one of the important by products of coconut tree and coconut-based activities. Husks are the outer fibre (35%) of the nut, followed by the hard protective shell (12%). Lining

the shell is the white coconut meat (28%) with a sweet coconut water of 25%. For using coconut, it is need to be dehusked for all purposes other than for seed and consumption as tender coconut. Dehusking of coconut is done at various stages in the marketing network. Except the husk obtained during dehusking at household level, the entire husk, including the unorganized marketing sector, reaches the coir industry, where it fetches a market value. In the coir industries, fibre is extracted from coconut husk. The thickness of the husk of an ordinary nut varies from 2.5-3.0 cm in the case of thin-husked nuts and 4.0-5.0 cm for thick husked ones.

Husks are useful source of potash and valuable mulch for the conservation of moisture. Husks are often burned to produce ash, which is used to fertilize the trees, burying the husk in the soil is more beneficial than burning. These husks are used as mulch for the conservation of moisture in the soil. A layer of husk is placed in a ring, convex side upwards from about 0.3 m upto a distance of 1.8- 2.1 m from the base of the palm. This method is beneficial during period of drought. Husks can also be used in planting holes during coconut seedling transplantation.

Utilization of coconut husk

Coconut husks are generally removed from whole coconuts at the farm site in close proximity to the trees from which they are harvested. After dehusking, the husks are piled and left to rot in the fields or normally burned as waste. A greater portion however, is used as fuel in farm site copra making. To a certain extent, husks are utilized in handicrafts, floor polishers and other minor applications.

To some degree also, coconut husk is used for coir fiber extraction. There are two methods of processing the coconut husk: namely, the manual and the mechanical processes. The manual process is simple and no investment for equipment is needed. The coconut husks are gathered and retted in a creek or waterhole for several weeks to loosen the fibers from the pith. The retted husks are then removed and pounded in a round rod to crush and separate the fiber from the pith. The product is a mixture of bristle and mattress fiber. This process is the most widely used in the Philippines because it is very efficient and needs shorter retting periods for the husk prior to debriefing process.

Coconut Husk Particle Boards: Merits of particle boards include saving of natural resources and waste utilization and this leads to environmental pollution control. Husk of matured coconut is unique raw material to prepare particleboards, in view of the fact that wood particleboards use 8-10 % adhesives on weight basis, while coconut husk boards require up to 0.25 % adhesives. However, care has to be taken to see that the ingredients in pith should not be allowed to separate out from the fibre, while the chips should be of free flowing nature. It should not inter lock into bundles during handling and storage. Such boards would give a density of 250 to 1300 kg/m3 (Table 7.3) and strength properties meeting relevant specifications.

Laboratory studies have also been carried out with husk as core wood basis, a surface to prepare layered particleboards. The layered particleboards showed good strength and low water absorption properties. These boards are found to be fire resistant. Studies have clearly shown the feasibility of preparing the particleboards using coconut husk and its by-products, which confirms to the

specification of wood. However, there is no structural study carried out to understand the observed properties.

Table 2.9: Properties of particleboard from coconut husk

Adhesive,%	Other adhesive, %	Density, kg/m3	Modulus of rupture, kg/cm2	Water absorption in 24 h, %
0.0	Paraformal-dehyde-1%	250	22	113.5
0.5	-	510	138	151
0.5	-	760	233	97.8
0.5	-	900	368	88.5
0.0	Paraformal-dehyde – 1%	1070	373	23.6
0.0	-	1210	365	16
0.0	-	1310	254	10.6

2.2. Processing of cocoa and value addition

This chapter describes the technology adopted in the processing of cocoa and its value addition to produce various cocoa based chocolate, confectionery and other food products containing cocoa. The cacao tree is native of America and may have originated in the foothills of the Andes in the Amazon and Orinoco basins of South America and spread to other countries within 15 degrees on either side of the equator including Mexico, Central America, Caribbean Islands, West Africa and South East Asia where the conditions for growing were ideal. In the 18th century the Swedish botanist, Carolus Linnaeus, renamed the cocoa tree giving it the Greek name Theobroma Cacao, now its official botanical name, which literally means 'food of the Gods'.

Cocoa is one of the economic tree crops grown in world. The Ivory Coast supplies 30% of the world's total cocoa, leading the rest of the world by over half a million metric tons with a total production of 1,448,992 tonnes. Companies like Nestle and Cadbury receive much of their cocoa from the Ivory Coast. The current production in India is about 13,000 tonnes. In India, it is mainly cultivated in Karnataka, Tamil Nadu, Andhra Pradesh and Kerala as an intercrop with Arecanut and Coconut. Slowly the area under cultivation is being promoted by many chocolate producing companies as contract farming.

Cocoa beans is mainly consumed as chocolate and widely used in cosmetics, pharmaceuticals, beverages, and health benefits such as anti-carcinogenic, anti-inflammatory, anti-microbial and analgesic. Cocoa husks can be hydrolyzed to produce fermentable sugar. Cocoa cake is used as part of feed ingredients for poultry, pig, cattle, sheep, goat, and fish after removing the theobromine. The shell (cocoa pod) is a good source of potassium and can be used in the production of potash fertilizer, soap, particle board and biogas. Fig. 2.42 describes the processing of cocoa beans involves the harvesting of cocoa pods, breaking of the harvested pods, fermentation of wet mass of cocoa beans obtained from broken pods, drying of fermented cocoa beans to moisture content of about 6 to 8% and storage of the dried beans till the time of use.

Harvesting and splitting of cocoa pods

The cocoa beans are derived from the mature cocoa pods and processed to get the end products. The cocoa pods contain beans, which are surrounded by pulp and mucilage. There are basically two colours for the pods. The change of colour of the pods indicates maturity. The green or green white pods turn yellow or orange, whereas red pods darken in colour as they ripen with traces of orange colour. The change in color starts from the grooves on the pods and then spreads to the entire surface. Cocoa pods take about 140 – 160 days to ripen. The cocoa is harvested in two seasons – April – August and October – January. Only fully mature pods are harvested. Pods are harvested by various forms of knife (Fig. 6.2). Care should be exercised to avoid damage to the flower cushion when pods are harvested. Harvesting may be

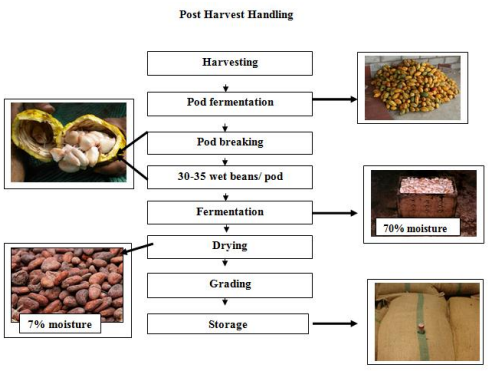


Fig.2.42: Processing of cocoa beans

done at 7-10 days interval. Fallen, disease infected, immature, over ripe and partially ripe pods are discarded. The pods should be kept for 2-4 days before they open.

For breaking the pods, wooden mallet or hitting the pods against hard surface may be resorted (Fig.2.43). The use of metallic knifes should be avoided to prevent damage to the beans. The placenta in the pods should be removed and the beans with adhering pulp are collected for fermentation. Beans are put for fermentation as early as possible after removing from the pod. For transportation of wet beans, non-metallic containers are used.

Fig.2.43: Harvesting and splitting of cocoa Pods

Primary processing

Primary processing refers to curing of wet beans extracted from harvested fruits. Curing of cocoa beans is very important. It comprises fermentation and drying. The chocolate flavor is developed in beans during this process. Fermentation of cocoa beans is essential to remove the adhering mucilaginous pulp to develop flavour and aroma precursors, reduce bitterness and kill the germ of the seed and to loosen the testa. Fermentation of beans is done immediately after extraction. The fermentation process is simple but must be carried out properly in order to get beans for good quality. It involves keeping a mass of wet cocoa beans, well insulated to generate and retain the heat and the same time allowing air to pass through. This process takes about 4-7 days depending upon the variety of beans. The pulp or mucilage sticking to beans then disappears (Fig.2.44). The colour of inside portion of the beans changes from purple or violet to light brown. The temperature of beans during the fermentation process must be stable at about 50oC. Small quantities of wet beans cannot be properly fermented because retention of the required heat is difficult. The removal of carbon dioxide surrounding the beans during fermentation is done by turning the mass.

Fig.2.44: Color changes of cocoa beans during fermentation process

Fermentation Methods

There are a number of methods of fermentation depending on the quantity of beans. Small quantities of wet beans (5-10 kg) can be fermented keeping them in small bamboo baskets. Large quantities (40-100 kg) need wooden boxes. If the quantity exceeds 200 kg, wooden trays or boxes can be used.

Box method

The wooden boxes of 60 cm × 60 cm × 45 cm having reapers at the bottom to allow the sweating from the pulp to drain out and provide aeration are used. The boxes could be arranged in tiers for transferring beans from one to the next in the line. Two detachable wooden planks are provided on one side of the box for transferring (mixing) the beans by removing the planks. The beans are loaded on fermentation box and covered with banana leaves or gunny bags (Fig.2.45). The mixing of beans is effected while transferring to the next box after 24 hours. The temperature of the fermentation mass will rise to 45-55oC after 48 h of fermentation. Every alternate day the beans under fermentation have to be properly mixed for uniform fermentation. This has to be continued for 6 days.

Fig.2.45: Fermentation of cocoa by box method

Basket method

In this method, bamboo or cane baskets of suitable size could be used for fermenting small quantity of beans. One or two layers of banana leaves are placed at the bottom with provision to drain the sweating. The basket is filled with the beans and the surface is covered with banana leaves (Fig.2.46). A small weight is placed over the banana leaves. The basket is placed over a raised surface to facilitate drainage of the sweating for one day. Later the basket is covered with thick gunny bags. The beans are mixed thoroughly on the 3rd and 5th days and again covered with gunny bags. The fermentation will be completed at the end of 6th day and the beans withdrawn for drying.

Fig.2.46: Fermentation of cocoa by basket method

End Point of Fermentation

Normally, some checks are carried out to determine the level of fermentation. Portions of pulp

adhering to the beans should be red-brown against original dull brown. The testa becomes loosened from the cotyledons. If fermented beans are cut, colour inside should be brown. The cut half of the bean when bent, should reveal irregular cracks on cut face. When above 50% beans in a lot show the above signs, it can be considered as properly fermented (Fig.2.47).

Fig.2.47: End point of fermentation

Drying

When fermentation is completed, the beans can be dried by sun drying. The fermented cocoa beans have considerable moisture (55-69%) and the drying rate is depending upon temperature and the airflow. Sun drying should be adopted as far as possible, as it gives superior quality produce compared to that by artificial drying. Commercially available cross flow electrical dryer is also used for drying of cocoa beans. The drying air temperature should be maintained at 70oC. The beans can be dried too quickly, which can result in the beans being very acidic. This can be overcome by using lower air temperatures, or an overnight rest period, to allow the moisture in the beans to equilibrate. The moisture content of well dried beans is around 6-7%. Slow drying is preferable for better quality of the beans.

Grading and Storage

After drying the beans it is necessary to carry out a hand-sorting or mechanical sieving/winnowing process to remove flat, slate, shriveled, broken and clumped beans and other extraneous materials. The cleaned beans are packed in fresh polythene lined (150 – 200 gauge) gunny bags or jute bags at the rate of 62.5 kg per bag. The bags are kept on raised platform of wooden planks. The beans should not be stored in room where spices, pesticides and fertilizers are stored as they may absorb the odour from these materials.

Proper Storage to Extend Shelf Life

Raw cacao beans will last for up to nine months in polythene-lined burlap bags when stored in a cool and dry location, with an ambient humidity level less than 70%. The plastic lining helps to protect the beans from odors, mold and pests. If the beans are stored at ambient temperature, which can turn rancid because of their high fat content. Cacao beans are subject to becoming rancid and over-fermenting when stored in temperatures greater than 77 oF.

Bean quality

Cocoa quality depends on various factors, but primarily on the cocoa variety and the post-harvest handling. Generally, fine or flavour cocoa beans are produced from Criollo or Trinitario varieties, while bulk cocoa beans come from Forastero trees.

Sampling

The sampler selects at random a significant percentage of the bags for inspection and a stabbing

iron is used to draw a number of beans from the selected bags. If the cocoa is in bulk, samples are taken at random from the beans as they enter a hopper or as they are spread on tarpaulins. The International Standard recommends that the samples should amount to not less than 300 beans for every tonne of cocoa. For bagged cocoa, samples should be taken from not less than 30% of the bags, and for bulk cocoa there should be not less than 5 samplings per tonne.

Cut Test

The samples are analyzed using the cut test. Most exporting countries' authorities specify standards dependent on the International Standards Organization (ISO) cut test, as do normal physical cocoa contracts. The cut test provides an assessment of the beans from which analysts may infer certain characteristics of the cocoa, which gives an indication of quality. The cut test involves counting of 300 beans. These 300 beans are then cut lengthwise through the middle and examined. Separate counts are made of the number of beans which are defective in that they are mouldy, slaty, insect damaged, germinated or flat. The results for each kind of defect are expressed as a percentage of the 300 beans examined. The amount of defective beans revealed in the cut test gives manufacturers an indication of the flavour characteristics of the beans.

Bean Counts Test

Bean counts are another measure of quality that producing countries often use, though there is no internationally accepted bean size classification. The Federation of Cocoa Commerce defines the following method for bean counts: A sample of not less than 600 g of whole beans, irrespective of size but not including flat beans, will be counted to obtain the number of beans per 100 g. Cocoa trade associations and national authorities produce standards for cocoa beans covering the bean count per 100 g and the percentage of permitted faults, moisture and foreign matter.

Nib Yield

For the chocolate manufacturer the yield of nib is very important, as is the amount of cocoa butter in the nib. Higher levels of cocoa butter mean that lower levels will need to be added later on in the manufacturing process.

Flavour Assessment

Flavour is also important for chocolate manufacturers. Flavour assessment is normally carried out by panels of between five and ten experienced tasters. Off flavors can readily be detected by tasting roasted ground nib of cocoa liquor directly or they can be mixed with sugar and water to make a basic dark chocolate before tasting. Mouldy and smoky off flavours and excessive bitterness cannot be removed during processing. Acid tastes can be altered in processing through neutralization.

Grade Standards

Cocoa shall be graded on the basis of the count of defective beans in the cut test. These standards are frequently based on the United Nations FAO model ordinance. Defective beans shall not exceed the following limits:

Grade I

(a) mouldy beans, maximum 3 per cent by count;

(b) slaty beans, maximum 3 per cent by count;

(c) insect-damaged, germinated, or flat beans, total maximum 3 per cent by count.

Grade II

(a) mouldy beans, maximum 4 per cent by count;

(b) slaty beans, maximum 8 per cent by count;

(c) insect-damaged, germinated, or flat beans, total maximum 6 per cent by count.

When a bean is defective in more than one respect, it shall be recorded in the most objectionable category.

Sub-Standard Cocoa

All dry cocoa which fails to reach the standard of Grade II will be regarded as sub-standard cocoa and so marked (SS), and shall only be marketed under special contract. Sub standard beans can be pressed whole to produce expelled cocoa butter which is then refined. Better quality beans are deshelled before pressing to produce pure pressed cocoa butter and cocoa press cake (which ultimately becomes cocoa powder). Chocolate manufacturers have a number of requirements with respect to the quality of cocoa butter such as hardness, melting and solidification behavior.

Final processing of cocoa

Final processing of cocoa means the transformation of cocoa into derivatives known as cocoa mass, cocoa butter and cocoa powder (Fig.), the principal raw material ingredients used in the manufacture of chocolates and any related cocoa based food products. The steps involved in the process as described below,

Cleaning

The lots of cocoa beans may contain foreign materials like stones, straw, jute threads, metallic contaminants which are removed by the process of cleaning involving operations like sieving, screening, magnetic separation and destoning.

Roasting

The cleaned cocoa beans are first inspected for moisture content and then classified based on colour. They are passed into roasters which reduce the moisture content, lower acidity and deepen the colour. Roasting is the most critical process which determines the quality of the resultant products with respect of flavor and colour. The cleaned beans are subjected to a temperature of 110-120oC depending upon the requirements wherein not only the residual moisture is driven out, but also develops the characteristic chocolate aroma. The whole process is carried out in a continuous roasting system wherein the hot air at the required temperature is deployed. Then the

beans are passed to dehuskers to remove the shells from beans.

Winnowing

A winnowing machine is used to separate the shells from the beans. It leaving only cocoa nibs and are conveyed for the next process of alkalization/milling. The shells are disposed of as fertilizers, mulch or fuel. In this process, beans lose weight by about 20%.

Alkalisation:

The colour and flavor of the cocoa is further enriched by the process of alkalization depends on the end use requirements wherein the acidity is regulated by neutralizing with alkali solution in a reactor under pressure. This increases the solubility of the powder. Direct steam is injected into the mass to debacterilise by sterilization technique. Then treated nibs are further dried to a moisture content of less than 1.5% in a continuous flow drier by using hot air.

Milling

The treated nibs are ground in pin mill until the friction and heat of the grinding reduces them into a thick chocolate coloured liquid called cocoa mass. It contains about 50-55% cocoa butter and can be solidified on cooling and becomes the basis of all chocolate and cocoa products.

Pressing

The cocoa mass is then subjected to powerful machines to extract the cocoa butter; the usual way of extraction is by means of hydraulic press. The cocoa liquor is subsequently passed through a cooling tunnel and solidified into liquor blocks or kibbled liquor. These processes constitute the first stage of conversion of beans into various products. In modern plants, all these activities are well integrated and mechanized and fully sealed. Once the beans are fed, cocoa liquor comes out packed, ready for distribution. In the second stage, the cocoa liquor is pressed to extract cocoa butter. The butter is then cooled and disposed of either in the form of liquid or slabs. Another product obtained is cocoa cake during the pressing of the liquor. The cake is pulverized and passed through breakers and grinders under controlled conditions of temperature and humidity to produce high grade cocoa powder for use as a beverage or cooking chocolate. The yield of cocoa mass from cocoa bean ranges from 78-82% depending on the quality of input beans yielding about 33-35% cocoa butter and 43- 45% cocoa powder.

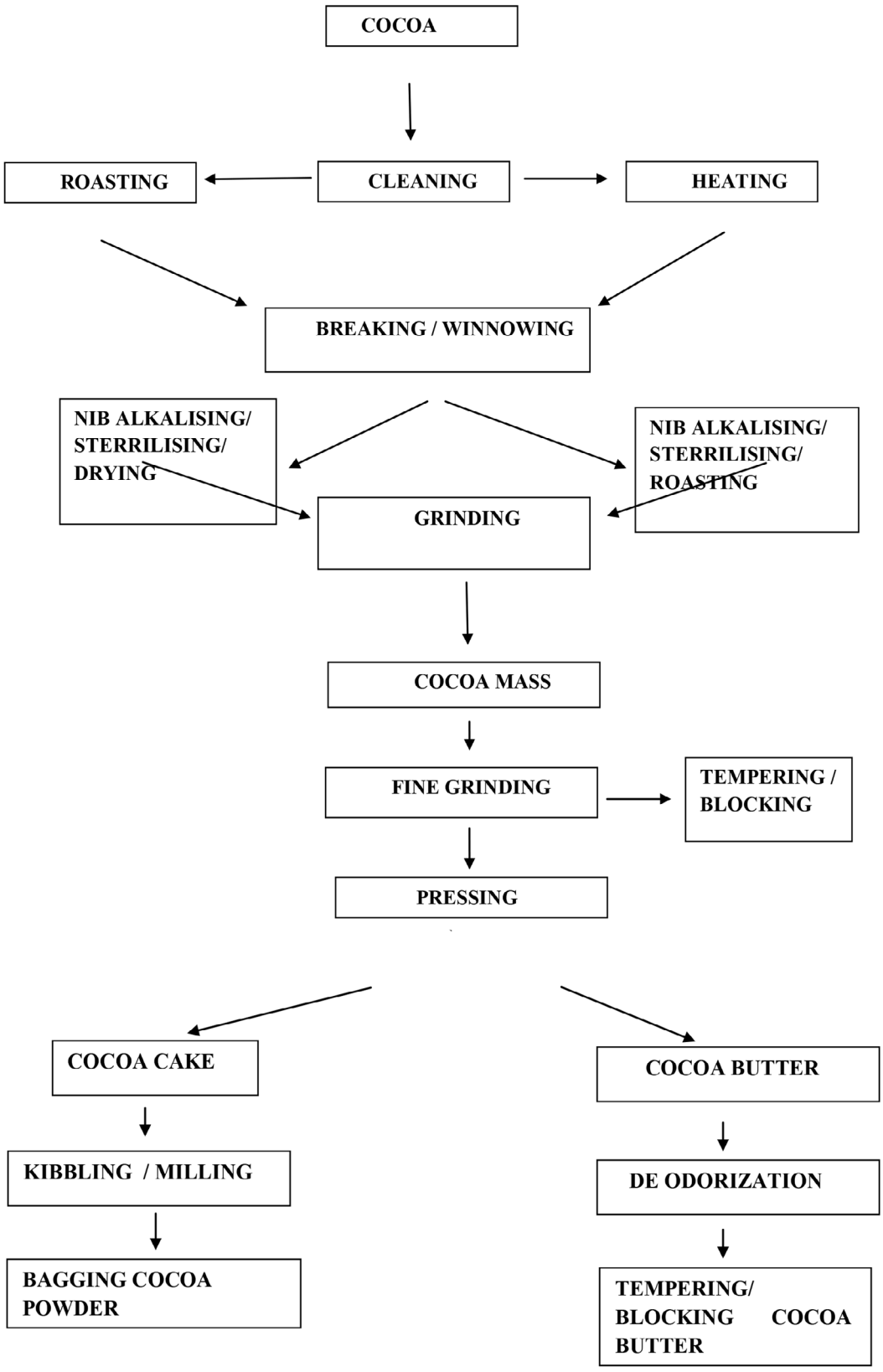


Fig.2.48: Process Flow - Cocoa Processing

Value addition of cocoa

Chocolate is homogenous smooth mixture of sugar, cocoa butter, cocoa mass, emulsifier with or without milk solids. In 1847, the first chocolate was produced in England. Later Cadbury exhibited their chocolate. Since then a lot of technological advancement came in chocolate manufacturing and currently world chocolate market is growing at 18% per annum. Based on the formulations a lot of variations are possible in the type of chocolates viz. milk chocolate, dark chocolate and white chocolates. Milk chocolates are manufactured by mixing the mass with cocoa butter, pulverized sugar, milk powder and lecithin. The resultant paste is refined over steel rolls in roll refiners.

The processes involved in the manufacture of chocolate are as illustrated below:

Mixing

Cocoa mass is used to produce chocolate with the addition of cocoa butter. Other ingredients like sugar, milk solids, emulsifiers are mixed together in a ribbon mixer till a homogeneous mass is obtained. The proportions of the different ingredients depend on the type of the chocolate being required.

Refining

The mixture then undergoes a process called refining wherein the mass is passed through rollers hydrostatically pressed to get a smooth texture to the product.

Conching

It is a process of kneading or smoothing process under controlled conditions of temperature under agitation where in the chocolate mass develops flavor and improvement in texture. To develop flavor, the paste is subjected to conching for 24-30 hours till the desired quality is obtained. Additional cocoa butter may be added at this stage and flavours at the end.

Tempering

Thus formed chocolate mass is subjected to a process called tempering wherein the mass is heated, cooled and reheated to the optimum temperature levels to prevent discoloration and fat blooming during the later stage of storage. This is mainly to bring all the butter crystals into a stable form.

Moulding

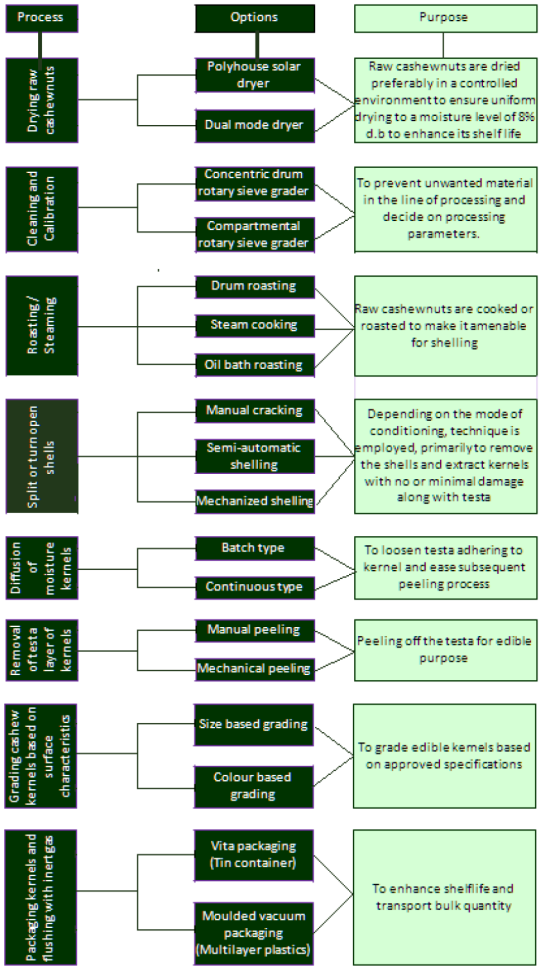
The tempered mass is then moulded into bars with or without inclusions and sold as moulded chocolates of required size and shape.

Thus produced chocolate can be used as a basis material for the manufacture of various chocolate products like count line bars, confectionery fillings, panned confectionery, bakery products, Ice cream industry and so on.

Other value added products derived from cocoa are as listed below:

1. Diabetic chocolates: Where sucrose can be replaced by other permitted sweeteners having low calorie along with cocoa mass and cocoa powder with or without milk solids.
2. Sugar confectionery: Cocoa butter can be replaced by fractionated palm kernel fat commercially known as cocoa butter substitute and use as a raw material in various applications.
3. Panned confectionery: The chocolate buttons or lentils are hard coated with sugar by the process of panning under controlled conditions of temperature and humidity.
4. Count line bars: Aerated nougat confections, wafers, biscuits, cereal bars etc., are coated with chocolate and are gaining popularity in the market.
5. Chocolate chips are gaining popularity in various food stuffs as an inclusion in cookies, ice creams, biscuits etc.
6. Various formulations containing cocoa is being widely used by confectionery industry as a centre filling mass in the manufacture of confections like éclairs, toffees etc.
7. Drinking chocolate powder with or without milk powder or malt is of another area which adds value to the cocoa based products.
8. Some formulations containing cocoa butter are becoming popular in the field of neutraceutical and cosmetic products.

Considering the health benefit of cocoa and its characteristic flavor, the consumption of cocoa based products is on the increase and expected to grow further in the years to come.



2.3. Mechanization and value addition in cashew

In the widespread spheres of production and utilization pertaining to the necessities of the life and uplifting its quality in the present world, mechanization in an appropriate level plays a crucial role. There is a pervasive interest in the development of cashew industry in India due to its potential to provide source of livelihood for the cashew growers, create employment opportunities and generate foreign exchange through exports. Although in its very birth place, North Eastern Brazil, the cashew, perhaps been neglected, it is well adopted to Indian soil and grown to greater extent. India pioneered in local utilization of the nut and its by-products, elevating the status of the nut as International commodity. For many years, India with her seemingly limitless low cost work force was the leading producer and processor of cashewnuts. Cashew kernels are a high value luxury commodity with sales growing steadily at an annual rate of seven percent, with every expectation that the market will remain strong. Mechanization in cashew cultivation is very much limited amidst growing problem of labour shortage and productivity turned out to be a serious issue due to widening gap between demand and supply. Labour oriented processing sector is gradually progressing towards complete mechanization.

Global perspective of cashew

Although cashew is native to Brazil, now it is grown in many other tropical countries. It suits very well to relatively poor soils wherein many other crops find difficult to grow. Cashew is primarily grown in the continents of Asia, Africa and South America. Asiatic zones mainly include India, Vietnam and Indonesia as the major cashew producing countries followed by Philippines, Malaysia, Thailand and Sri-Lanka. African countries producing cashew are Côte d'Ivoire, Nigeria, Tanzania, Mozambique, Kenya, Benin, Guinea- Bissau, Mozambique, Ghana, Senegal and Madagascar. The primary producers in the Latin American zone are Brazil, besides Columbia, Costa Rica, Honduras and Salvador. Vietnam and India are the leaders in processing cashewnut and earn more foreign exchange through value addition. Although, African zone recorded the highest production of raw cashewnuts, due to improper mechanism in place, majority of harvested nuts are exported to other countries loosing additional revenue. Zone-wise production scenario of cashew in the world since 1961 is illustrated in Fig. 2.49. Global cashew production had been dominated by African zone during 60's and 70's and later it declined to 36% in recent times.

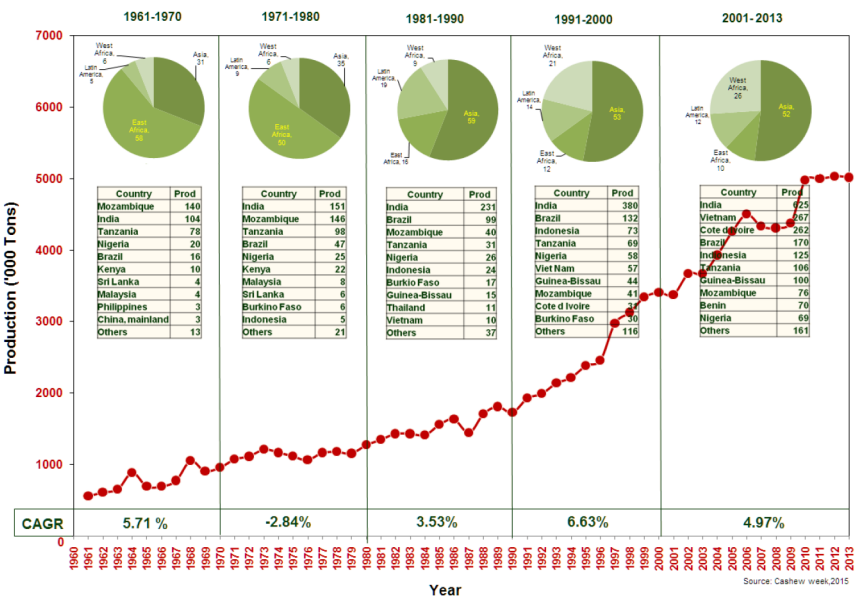


Fig.2.49: Zone-wise production of cashew in the world (1961 to 2013)

The world annual production of cashew kernel is about 0.63 million tones with an estimated value in excess of US$ 4.69 billion.

Among them, Cashew ranks fourth accounting for about 13.9 % next to Almond (24.7%), Pistachio (21.8%), Walnut (19.1%) and ahead of other tree nuts viz., Hazelnuts (11.0%), Pecans (3.9%), Pine nuts (3.3%), Macdamia nuts (1.7%) and Brazil nuts (0.62%), making cashew production the subject of interest for development agencies, producer governments and advocates sustainable economic and environmental development.

Production and processing of cashew in India

Cashew cultivation was very much confined to the western and eastern coastal areas of the peninsular region after its introduction in India during the sixteenth century. Presently, it is more concentrated in the Maharashtra, Goa, Karnataka and Kerala all along west coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal in the east coast. Besides, it is expanding in non-traditional regions viz., Chhattisgarh, Jharkand, Gujarat, Assam, and Northeast Hill Regions and also in Andaman and Nicobar Islands. In India, cashew is reported to be grown in an area of 10.08 lakh ha with the annual production of 7.37 lakh MT of raw nut and its average productivity centres around 782 kg/ha during the year 2013-14 (Table). At present, Maharashtra state ranks first in production with a total production of 2.36 lakh MT with productivity of 1317 kg/ha in the country.

Table 2.10: Area, production and productivity of cashew in the different states of India (2013-2014)

State		Area (000' ha)	Production (000' MT)	Productivity (kg ha^{-1})
West Coast	Andhra Pradesh	184.85	100.42	646
	Odisha	166.91	85.71	679
	Tamil Nadu	139.42	67.39	669
East Coast	Goa	57.97	32.35	780
	Karnataka	124.11	80.61	750
	Kerala	84.93	80.12	910
	Maharashtra	184.2	236.2	1317
Others (Plain and Hilly)		65.31	53.76	739
Total		1007.70	736.56	782

Over a period of time, a phenomenal growth is evidenced in the total quantity of raw cashewnuts processed in India. The pioneering spirit of the early entrepreneurs and the unsurpassed skills of Indian women in extracting whole kernels from the nuts were the major factors influencing the birth and growth of cashew industry in India and for her preeminence as the world's largest processor

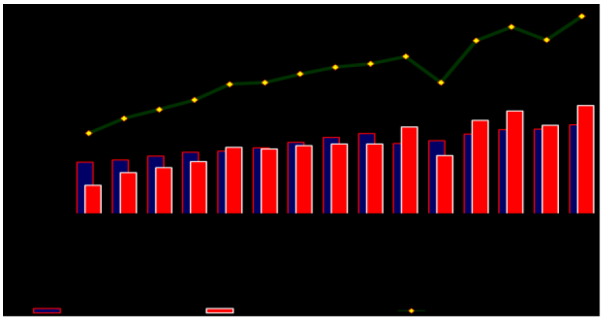


Fig.2.50: Cashewnut production and processing in India

and exporter of cashew kernel. A record quantity of 17.13 lakh MT of raw cashewnuts are processed during the year 2014-15, equivalent to 39 % of the global production. Although, a steady growth in the quantum of raw cashewnuts processed in this country, contribution of domestic nuts in the processing declined from 85.85 % during the year 2001-02 to 45.13 % during the year 2014-15 (Fig.2.50). Increasing competition in international market is posing new challenges to Indian cashew industry. Inadequate supply of raw cashewnuts is a long standing problem primarily due to low productivity.

In order to full fill the demand of cashew processing industries, a quantity of 9.82 lakh MT of raw nuts valued at Rs 6150 Crores, was imported from African and Asian countries during the last fiscal. It is suggested that to resolve the problem, possibly, area under cashew can be expanded to enhance productivity. Since marginal or degraded lands are chosen for cashew, obviously, substantial contribution by area expansion is highly difficult. As a last option, increasing yield per unit area appears to be sensible approach to regain India's last position. Indian cashew is renowned worldwide for its superior quality, taste and appearance. The demand is ever increasing for kernels in domestic and international markets. About 1.18 lakh MT of cashew kernels has been exported to USA, The Netherlands, UK, Japan, UAE etc., during the year 2014-15, earning a foreign exchange to the tune of Rs 5433 crores. Besides, Cashew Nut Shell Liquid (CSNL), an important by-product of the cashew processing industry is also exported worth of Rs 55.81 crores during the same period.

Status and scope of farm mechanization in Cashew

Fig. 2.51: Cashew tree in the orchard

Cashew (Anacardium occidentale L.) is an evergreen plant that grows with its spreading branches into a big tree in nature and remains productive for several years provided the conditions are conducive (Fig.2.51). However, the growth patterns depend upon environment, soil factors and competition from neighbouring trees for sunlight. Till recently, it was considered as a forest species and encouraged to promote afforestation to conserve soil. However, it is now considered as horticultural crop and well recognized as a major export oriented commodity for its nutrient rich tasty kernel. Concerted effort by the scientific and development front in India made it as highly lucrative crop and presently, it is expanding in non-traditional areas i.e. plains and hilly regions also. As such, the degree of mechanization in cashew cultivation is very much limited, this plantation need cost effective labour economizing technologies in order to overcome the shortage of agricultural laborours, encourage farming community and promote this highly profitable crop.

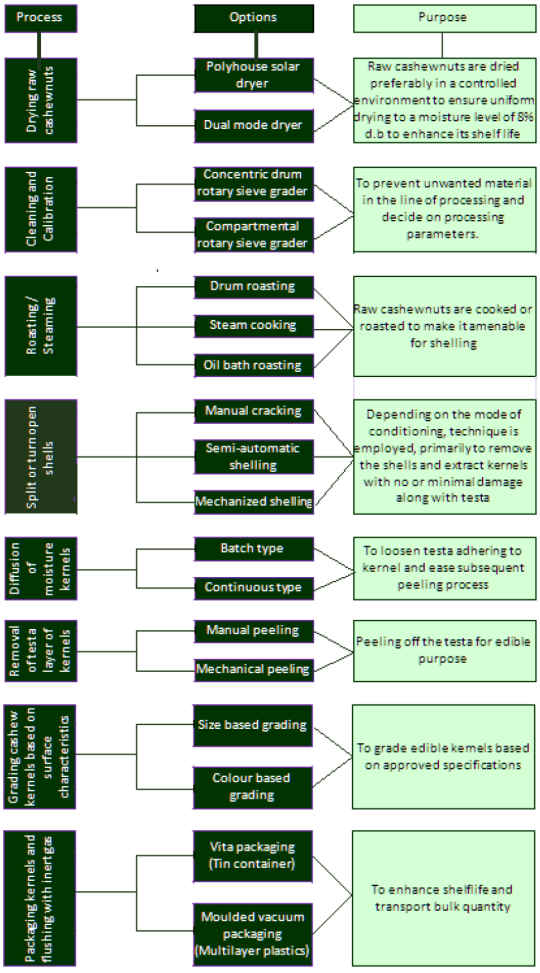
Harvest and Post harvest

Cashewnut is naturally attached to juicy apple and falls by gravity after full maturity. Presently, economic importance is given to cashewnut only while the nutrient rich apple is being wasted due to lack of awareness of its consumption in any form or as value added products. Since apple is being highly perishable commodity, the apple needs to be harvested before the fall on ground for

which devices needs to be developed, provided utilization of the apple is popularized. Although method of harvesting the nuts and apple can be thought of by mechanical vibration of the tree during harvest time, cashew apple should be sufficiently protected against physical damage and at the same time, detachment of flower should be totally avoided.

Mechanization in cashewnut processing

India is regarded as the home of cashewnut processing and continues to be the dominant force in the market with an efficient processing industry for several years. Owing to dexterity of work force in extracting the white whole kernels which fetches premium price, it maintained superior position in the International trade. In recent years, Vietnam has taken over as the premier exporter of kernels but India remains the largest processor by far. The objective of processing cashewnuts is to remove the highest possible weight of kernels from the nut in-shell, unbroken and with the distinctive light ivory cashew color. Although it is a material separation process, since it is a food product, care should be taken to retain the taste as natural as possible and the process should be done in a safe manner. The engineering phase of cashewnut processing deals with the processes involved to change or alter the raw cashewnuts by the application of various unit operations and the machinery to the desired level.



Essential unit operations in the line of processing and technique involved with purpose are depicted in Fig.2.52. Cashewnut processing in India can be categorized in to three groups on the basis of machinery utilization. They are, i) Manual process, ii) Semi-automatic process and iii) Advanced processing with automation. Traditionally, cashew processing in India, considered as labour oriented and low investment activity with minimal use of technology. Open pan roasting is a manual processing method and it is still prevailing in rural areas located in production catchments. In this method, nuts are subjected to heat over shallow pan and stirred continuously. The oil exuding from the pericarp catches fire and at the appropriate time the pan is lifted and the contents emptied on the ground. The flames are extinguished by splashing water and the ash spread on the nut to absorb oil for protecting hands while cracking the nuts (Fig.2.53.).


Fig.2.53: Open pan roasting of cashewnut

Although various mechanized equipment were developed globally for different operations in the line of processing

during 60's, it could not attract Indian processors primarily due to twin reasons viz., availability of adequate work force having dexterity to extract whole kernels and the low performance of developed processing machines. In drum roasting and steam boiling techniques adopted in majority of processing units' deployed men and machinery at various stages of processing relative to the profitability. Highly skilled personnel are engaged in shelling, peeling and grading whereas, machinery are involved for various other activities viz., nut conditioning, kernel drying and packaging.

Fig.2.54: Cracking of roasted cashewnuts

Cashew business expanded tremendously over a period of time, providing more opportunity for the new entrepreneurs to plunge in to this business. Spurt in the cashew value chain and employment creation in other sectors led to non availability of skilled work force in this system and presently these industries are gradually progressing towards complete mechanization. Mechanization followed to extract edible kernels from raw cashewnuts, cashewnut shell liquid from shell, juice extraction from cashew apple and kernel roaster for value addition are detailed below.

Drying raw cashewnuts

Fig. 2.55: Dual mode dryer for raw cashewnut

Raw cashewnut is made up of three different portions viz., the shell, the kernel and the adhering testa. Cashew processing is a tedious and arduous task because of the irregular shape of the nut, the presence of tough outer shell and the corrosive CNSL within the shell. Raw cashewnuts after harvest has moisture content in the range of 14 to 17 % d.b. and need to be dried to 8% (d.b) for extended shelf life. Normally harvested nuts are sun dried for 2 to 3 days to reduce its moisture to safer level. Direct sun-drying and the use of solar driers depend on the intensity of the sun light to effect drying. Dual mode dryer exclusively developed for raw cashewnuts is a batch type and suitable for cashew growing regions wherein harvesting coincides with monsoon rains to extend its shelf life. Average time required to reduce the moisture content of raw cashewnuts is in the range of 3.16 to 4.41 hours in the case of utilizing electric power and 4.11 to 4.38 hours by employing thermal power for various size nuts (Fig). Energy utilized to reduce moisture to safe level is 32.93 MJ and 201.71 MJ for electrical and thermal power respectively. Cost of drying raw cashewnuts using dual mode dryer is worked out to be Rs 0.45 per kg.

Grading

Raw nut grading is the first step in mechanization of cashewnut processing. Size based distribution of nuts to be processed is a reasonable indicator towards product standardization. Providing graded nuts can improve efficiency of subsequent operations. Grading nuts at preliminary level can ensure control over kernel drying cycle for better white whole kernel recovery and minimize

work load at kernel grading stage. Compartmental sieve grader developed by Oltremare, Italy is the first of its kind. Concentric drum type rotary sieve grader developed at Directorate of Cashew Research, India has the advantage of compactness and higher grading efficiency. Various machine parameters viz., sieve and cylinder diameter, sieve cylinder length, slope of the cylinder and its rotational speed and material parameter viz., bulk density and feed rate were optimized for better grading efficiency (Fig.2.56). Operational capacity and grading efficiency were found to be 292 kg/ h and 97.58% respectively.

Fig.2.56: Grader for raw cashewnut

Conditioning raw cashewnuts

Adherence of testa, the layer surrounding the edible kernel with endocarp is very strong in the harvested nut and pose problem to extract kernels in whole form. Conditioning of raw cashewnuts, loosen the kernel within the shell to make it amenable for extraction of whole kernel during manual or mechanical shelling. Thermal treatment of nuts facilitates shrinkage of kernel inside and ease de-shelling process with minimal breakage. In general, three different modes of conditioning process are employed in cashew industry viz., Drum roasting; Oil bath roasting and Steaming nuts.

Drum roasting process

Drum roasting consists of feeding tank constructed at raised level so as to mobilize raw nuts to rotating drum by gravity. The drum is fabricated using mild steel sheet of 0.6 cm thickness to withstand high temperature. A normal slope of 4□ is given from inlet to outlet of drum, which is fixed after conducting several trials on different slope in connection with residence time of nuts inside hot chamber. Water is sprinkled at the drum outlet to cease fire on nuts. About 64 % of the total processing units operating in India follows drum roasting process. During drum roasting process, dried nuts having moisture of ≈8% d.b are fed into an inclined rotating drum which is heated initially to such an extent that the exuding oil ignites and burns, thus charring the shell (Fig.2.57). The drum maintains its temperature because of the burning cashewnut shell liquid (CNSL) oozing out of the nuts. Roasting generally takes about 10 to 15 sec and the drum is rotated by hand during this period. The roasted nuts, which are still burning are quenched off by sprinkling water and covered with ash to absorb the oil on the surface. The shell becomes brittle and the outturn of whole kernels reported to be highest among the three methods of conditioning process. Smoke emanating from drum roasting process is let in to air at height of 20 m through brick constructed chimney. Feed rate and rotational speed of the drum are considered as prime factors which decide the quality of kernels after roasting.

Fig. 2.57: Drum roasting machine

Motorized compact type drum roasting machine developed for pre-conditioning raw cashewnuts could be operated by 0.74 kW and it can be operated by unskilled laborers. LPG could be used

as thermal source and the drum temperature can be adjusted precisely. Raw cashewnuts can be transferred from feed hopper to the roasting drum through bucket elevator and the feed rate can be adjusted to the required quantity. Since various processing parameters influencing the final quality of edible kernels during drum roasting of raw cashewnuts are optimized, processors' can achieve end product with desired qualitative and quantitative efficiency easily. Pollution control gadget i.e. water scrubber system developed by Cashew Export Promotion Council (CEPCI), Kollam accepted by Control board authorities and it is expected that drum roasting process hereafter can be operated with environmental safety.

Oil bath roasting

Oil bath units consists of a large rectangular bath filled with CNSL mounted over a grate furnace which uses spent cashew shell as fuel. Initially raw nuts are conditioned by soaked in silos for a specific period depending on the moisture content and origin of the nuts. Theses pre-conditioned nuts are lifted by bucket elevator and transferred in such a way that it forms a thin layer on an endless conveyor chain with cross ribs. These nuts are carried all along the bottom of the hot oil bath wherein CNSL is maintained at a temperature of 190-195°C and discharged above the oil level at the other end in a short period of 10-15 sec. Nuts get cooked while moving all along the oil bath and oozing out oil from the shell. Residual oil on the surface of the roasted nuts is removed by spinning action in the centrifuge. This mode of processing is now obsolete in India due to huge investment on machinery and discoloration of cashew kernels.

Steaming process

Fig. 2.58: Centralized steaming system

Conditioning of raw nuts i.e. alternative wetting and drying process, facilitate extraction of whole kernel during mechanical shelling. Majority of the processing units utilizes 'twin bottle type steam boilers' for the purpose of conditioning raw nuts. Steaming of raw cashewnuts is a batch process and it consists of a cylindrical drum with a hopper on the top to feed raw cashew nuts. A boiler is used to generate steam and fitted with pressure gauge. Generated steam is passed into the cylinder through a pipe at the base and connected to a perforated central stem and laterals inside the drum. A valve provided facilitates to control the supply of steam to the nut chamber. At present, centralized steam generation system with multi chamber (3 nos.), increased the production rate and utilize the fuel economically (Fig.2.58). Manual transfer of raw cashewnuts in to the nut chamber for conditioning process is now replaced by bucket elevator, saving time and labour. Rotary type 'Steam kettle' ensures uniform conditioning process and preferred for handling bulk quantity Steaming parameters need to be optimized for better whole kernel recovery and combining product value and quality index, processing parameters were optimized for raw nuts of Nigerian origin.

Shelling cashewnuts

Once the nuts become hard and brittle after roasting or steaming process, individual nuts are split open manually using a shelling gadget to set free the edible kernel. Demand of highly skilled work force and non availability of adequate labour for shelling i.e. extraction of edible kernel from conditioned raw cashewnuts either by roasting or steaming led to mechanize this operation. The mechanization introduced in cashew industry has been in the form of cutting apparatus for nuts in Mangalore. Various decorticating methods, which have been tried in the past, are i) Explosive decompression of the nuts by which the kernel emerge through a natural point of weakness of the shells; ii) Freezing the nuts and break by standard centrifugal nutcracker and iii) Cutting the shell around its major axis to allow the kernel to be exposed.

During the development of single nut cutter, combined cutting and wedging operation in the plane of symmetry of the nut i.e. previously roasted under controlled conditions was employed for splitting along the natural plane of weakness in the shell. Later, the hand lever operation is converted to foot operation, leaving both hands free, one for the transfer and location of the nut and the other for the adjustment of the pillar height to suit the size of the nut. In oltremare system, Italy, the shells were cut longitudinally and separated by a pair of gripers freeing kernel with the outturn of 80 % of whole kernels. In another version, the foot operated lever pushed the anvil upwards against the cutting blade, which is held in an adjustable slide and on release returned upwards by a spring.

A power-operated cashew nut sheller is developed based on the principles of compression and shear. Feed hopper and horizontal screw conveyor provided positive feed of the roasted nuts to the shelling section. Roasted nuts are shelled between two wooden discs, of which, one is stationary i.e. fixed to the casing and the other one mounted on the shaft. The rotating disc is a spring loaded one to exert sufficient pressure to compress and shear the roasted cashewnut against the stationary disc. The rated capacity of the sheller was observed to be 18 kg h-1 of roasted nuts with shelling efficiency of 70 %. Yield in terms of whole and broken kernels are 22% and 28 % respectively. The Kerala Agricultural University model is a manually operated cashew nut decorticator having top blade assembly, 2-blade bottom assembly and a linkage assembly fitted on a worktable. The 2-blade bottom assembly is made to slit the convex portion of the cashew nut and split the shells after cutting. Shelling efficiency is 88 per cent of whole kernels and the operational capacity is 900 nuts h-1. The single nut cutter developed by Mechanical Engineering Research and Development Organization (MERADO), Kalamassery, Kerala to shell the roasted nuts, separates kernel by hand cum foot-operated mechanism. The decorticator can conveniently be mounted on a work table and worker can operate it in a sitting posture.

In radial arm type cashew kernel extracting machine developed at Directorate of Cashew Research, Karnataka, single operation enables cashewnut holding and subsequent splitting (Fig. 2.59). Raw cashew nut is placed in between blades with its notched portion facing the holder blade and convex side resting on the edges of twin blades. The lower part of the twin blade aids in proper positioning of the nut. When the pedal is pressed, sliding arm move onwards and holds the nut. Further pressing make the cam to slip and allow the second cam to push the sliding rod to rotate the disc to a set angle. This helps the outward movement of twin blades resulting in splitting of shells. The compression spring provided ensures the whole assembly back in position after the release of force

applied on pedal.

Nuts are regulated from hopper through revolving off-set disc assembly in the automatic cashew desheller developed in Kollam, Kerala (Fig.2.60). Singulated nuts from hopper are conveyed forward to deshelling point by a moving belt and it requires suitable belt for specific grades of nuts. Each nut is held between two blades and split open by lifting one of the off-set blades. Shelled nuts and kernels are cleared by a pusher to clear the space between two blades for the next nut in conveyor line to be shelled. Cutting and split blade assembly is adjusted according to the size of the nut i.e. width of the nut for better shelling efficiency.

Fig.2.59: Radial arm type cashew kernel extractor

Fig.2.60: Automatic cashewnut de-sheller

Fig.2.61: Vertical type reciprocating mechanized sheller

In the top driven mechanized sheller, conditioned nuts in the feed hopper are lifted up vertically by sliding component and transferred to the funnel. After positioning the nuts in the channel, nut is pushed down by a shoe against V- shaped blade. Due to the application of high force, nuts slits around its contour and split open by the blades provided on either side (Fig.2.61). Each machine is provided with two such shelling mechanisms deriving mechanical power from 0.37 kW single phase electric motor. Operational capacity is found to be in the range of 7.93 to 10.18 kg h-1 with whole recovery 98.63 %.

Fig.2.62: Steam assisted dryer

Drying unpeeled cashew kernels

Dryers employed in majority of the Indian cashewnut processing units have either natural or forced convective system. Accounting the problems of non uniform drying, high thermal energy loss, increased cost of drying, reduce environmental degradation, a novel dryer which works on the basic principle of heat exchange of super heated steam through radiator and fins assembly is developed. It controls air temperature more precisely ensuring uniform drying and minimize the energy during the process (Fig.2.62). This cross flow dryer is a double walled design with its annular space filled with glass wool to provide thermal insulation. Two steam heat exchangers i.e. radiators and fins assembly are fitted diagonally opposite to each other. Externally generated steam is passed in to the heat exchangers to transfer heat for drying process inside the dryer. Assessment on the performance of this steam assisted dryer indicated that it improves peeling ability and quality of cashew kernels in terms of surface colour. Total energy required to operate steam assisted cross flow dryer was found to be 16.49 % lesser than existing convective type dryer.

Peeling cashew kernels

Peeling is the process of removing adhering testa layer surrounding the edible kernel. Various types of automatic peeling machines viz., brush, abrasion and impact type are introduced in the Indian cashewnut processing industry recently. Brush type peeling machine is indigenously developed and has rotor with stiff bristles to peel off the kernel testa after steaming (Fig.2.63). Steam treated and dried unpeeled cashew kernels are mechanically peeled and its operation capacity is 300 kg h-1. Peeling efficiency recorded as 84 % with whole kernel recovery of 69%.

Abrasive type peeling machine is also developed in India and it consists of feed hopper, conveyor, peeling drums, compressor and products outlets (Fig.2.64). Dried unpeeled kernels are humidified to increase its moisture content to specified level. During peeling operation, unpeeled kernels were subjected to abrasion against inner surface of the drum due to centrifugal force. Rotational speed of the abrasive drum and time of peeling are prefixed to control peeling operation inside abrasive drum. High pressure air generated through compressor aided in removal of loosened testa. An automatic peeling machine imported from Vietnam consists of feed hopper, bucket elevator, peeling drum, pneumatic separation, and a kernel grader. Peeling shaft is fixed eccentrically inside a perforated drum and revolves in opposite direction.

Fig.2.63: Brush type peeler

Fig.2.64: Abrasive type peeler

Fig. 2.65: Impact and shear type peeler

Humidified unpeeled cashew kernels are subjected to impact and shear force by numerous spring loaded hook like structure mounted on central shaft (Fig.2.65). Afterwards, kernels were passed in to the pneumatic system to remove loosened testa and aspirated by a cyclone separator. Peeled and unpeeled kernels were conveyed to rotary kernel grader for segregation. Peeling capacity and whole kernel recovery found to be 273 kg h-1 and 80 % respectively.

Grading and packaging

Cashew kernels are graded based on the wholesomeness, size and colour as per the specifications prescribed by the by Govt. of India under the export (Quality control and inspection) Act 1963, which recognizes 23 different export grades of kernels. Although manual grading is practiced in India, mechanized divergent fluted rollers are used for grading the kernels based on size. Rotary or reciprocating sieve graders are mainly used for segregating low grade kernels viz., Large white pieces (LWP), Small white pieces (SWP) and Baby bits (BB) (Fig.2.66), Colour graders which works on the principles of spectral reflectance of light indicating the surface colour of kernel,

is gradually making a breakthrough in cashew processing system in India. Surface colour of cashew kernels is one of the physical attributes to determine the quality in cashewnut processing industry. A high speed colour sorter suitable for cashew kernel is evaluated for its performance in terms of operational capacity and purity index. Certain grades of whole kernel and broken kernel grades with different proportions are used in the present investigation. Operational capacity recorded significant difference among the grades investigated with higher value of 156 kg h-1 for the largest kernel (WW 210) and 52 kg h-1 for the smallest kernels (BB). Purity index showed dependency on size of kernel and influenced by proportion of the kernels. Cost economics indicated that mechanical grading saves 40% of the total cost incurred for manual grading of cashew kernels.

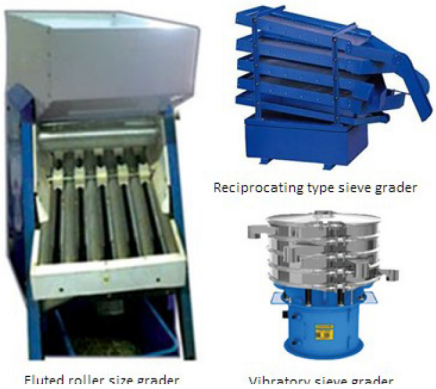


Fig.2.66: Graders for cashew kernels

Packaging of kernels

The graded kernels are packed in 11.34 kg capacity tins which are subsequently evacuated and infused with carbon dioxide gas with the help of packing unit called "vita pack" to suppress the possible insect attack (Fig.2.67). The packed tins are then labeled as per the grades across the lid using special tamper proof adhesive. Two tins each containing 11.34kg cashew kernels are packed in corrugated carton box, which are bound by nylon strapping for export. The standard markings including brief description, name of packer, gross and net weight etc. are printed on the carton. Introduction of alternative method of flexible packaging i.e. Mould vacuum packaging (MVP) with nitrogen as inert gas is gradually gaining importance. MVP system produces consistent rectangular blocks ranging in size from 500 g to 25 Kg. This gives a large and obvious improvement in the quality production with benefits of minimum movement in transit, handling, display, stock count etc.

Mechanization in cashew by-products

Cashew apple and cashewnut shell liquid (CNSL) are the two major byproducts of cashew industry. Technical know-how is available for the preparation of juice based products like ready to serve beverage, squash, syrup, jam, pickle, animal feed and alcoholic beverages like fenni, vinegar, wine etc., CNSL is a versatile industrial polymer and find application in the formulations of paint, varnish resin, laminates, brake lining, rubber compounding etc.,.

Cashew apple juice extractor

In Goa, extraction is done in specially prepared depressions made by carving stones, locally known as "Kolambi", followed by keeping the residue under heavy stone to squeeze out the juice

completely. Cashew apple juice can be extracted up to 50 % by following hand pressing technique. Extraction efficiency could be enhanced by using screw press, basket press, cashew juice expeller or hydraulic press. A manually operated cashew juice extractor operating on screw press principle was designed, constructed and tested. Apple crushing was by pressing a wooden piston against a steel reinforced end plate. Juice output was 1.02 L h-1 and the average juice extraction efficiency was 85.4 %. Investigations conducted at CFTRI, Mysore revealed that extraction of juice by screw type extractor and subsequent pressing of the residue in basket press yielded higher quantity of juice. Moreover, it is indicated that one litre of juice could be extracted from 3.5 kg cashew apple. A 2-Ton load hydraulically powered cashew apple juice extractor was developed and tested at ICAR-Directorate of Cashew Research, Karnataka, India. The unit consists of a cylindrical vessel having capacity up to 10 kg of cashew apple, a piston and ram assembly with wooden disc to apply required load. A power pack system for fluid regulation operated by 0.25 hp single phase electrical motor (Fig.2.68). Basic trials with cashew apple revealed that juice extraction efficiency ranged from 81.6 to 89.2 % after 2nd pass.

Fig.2.68: Juice extractor for cashew apple

Extraction of cashewnut shell liquid (CNSL)

Cashew shell having brown viscous liquid present in honey comb structure, commercially known as Cashewnut Shell Liquid (CNSL) provides a natural protection to the edible kernel against pest or insects. CNSL, which is pericarp fluid of the cashew nut constitute Anacardic acid (90%) and Cardol (10%) when extracted with low boiling petroleum. In oil bath method, the raw nuts are passed through a bath of hot CNSL (180-200°C) itself, when the outer part of the shell bursts open, it releases CNSL (50% recovery). Another 20% could be extracted by passing the spent shells through an expeller and the rest by solvent extraction techniques. The expeller oil gets upgraded by acid washing followed by centrifugation and heating. In another method, raw cashew nut shells are transferred to the hydraulic press and high pressure is exerted through revolving screw in order to release CNSL (Fig.2.69). Experiments conducted with such system revealed that the CNSL can be extracted in the range of 20.65 to 21.04 % with the purity of 85.53 to 87.8 % by weight basis when the screw speed was maintained between 7 and 13 rpm and feeding rate of 54 to 95 kg h-1. Besides, the rate of extraction was computed to be in the range of 11.93 to 14.90 kg h-1. However, the residue from this method still contained significant proportions of CNSL i.e. 10 to15%. The CNSL obtained by this process contained 42% cardol, 47% anacardic acid and 3% cardanol. CNSL can be effectively extracted by solvent extraction or using super critical carbon-di-oxide or by column chromatography in a laboratory scale.

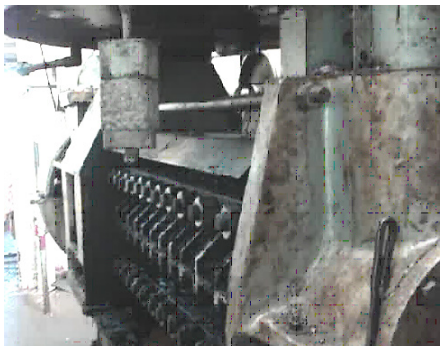


Fig.2.69: CNSL expeller

Briquetting machine for cashew shell cake

Biomass briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Trials conducted with ram type briquette making machine revealed that briquettes could be made using cashew shell cake (CSC) in pulverized form and saw dust with the impact force i.e. 1200 kg cm-2, but developed cracks at disc joints of the briquettes (Fig.2.70). Particle size of cashew shell cake, moisture content of saw dust, feed rate, stroke length and oil content of mixture influences the formation of briquettes and its stability. Moreover, cashew shell obtained from drum roasting process i.e. partially burnt shell can be carbonized completely by retort method and converted in to carbonized briquette using roller press for value addition to cashew byproduct.

Fig.2.70: Briquetting machine for CSC

Updraft gasifier for cashew shell cake

Cashew shell cake based updraft gasifier consisted of a reactor serving as gasifying media, blower to supply air, ash outlet and producer gas outlet connected to a burner as shown in Fig.2.71.

Average flame temperature and period of generation of producer gas ranged from 437 to 456°C and 36 to 66 min. while varying the feed stock of cashew shell cake from 3.5 to 14 kg in the updraft gasifier. Moisture content of the feed stock plays an important role in the gasification process as evident from thermo gravimetric analysis. Besides, it also indicated that a minimum of 8 to 15 minute is required for initiating the generation of producer gas depending on the moisture level. Average flame temperature recorded was 434 to 451°C for the moisture level of feed stock in the range of 3.74 to 9.35 % d.b.

Fig.2.71: Updraft gasifier for CSC

Assessing need of processing machinery

Selection of appropriate machinery in cashew industry should be suggested based on operating capacity, electric power requirement, availability of technical man power, and market access. As the cost incurred on raw material is more or less 70 % of the total processing cost in cashewnut processing, machinery installed need to be utilized to its fullest capacity to make it economically viable. Location of the plant is important in terms of access to raw material, factors influencing the operation of sophisticated equipment installed, storage of raw material, access to spare parts and access to utilities. A good knowledge on basic information about raw material viz., expected yield at packaging, size of the nuts, the moisture and variation over the year, the ease of peeling, the thickness of the shell and the oil content of the nuts in order to decide on the type of machines to be purchased. Besides, careful planning is required to install sophisticated equipment in remote areas keeping in mind the communication facility and electric power supply. Technical personnel should be available or trained to operate the sophisticated machines without problem and attend

to repair and maintenance work for continuous operation. It is important in assessing equipment options to consider workers ability to work with the equipment in the factory. Purchasing of equipment involves capital investment, planning and management of resources and logistics. It is very important to consider the economics of cashew equipment to assess long term market and not short term trends.

Transforming cashew Industry in to modern, efficient, economically viable and sustainable that competes effectively in the global market is the way forward. Interventions that target development constraints and opportunities at the various levels of the cashew value chain includes farm mechanization towards sustainable cultivation, exchange of information among chain actors, the use of cost effective processing technologies, innovative market approach etc., and need of the hour to be strengthened. In the face of increasing resource constraints i.e. land, labour and water, new resource conserving technologies must be developed and adopted. In India, mechanization in cashew cultivation is in an infant stage as it is primarily grown in degraded and unutilized land. At present, as a prerequisite, certain farm machineries are utilized for various operations related to nursery, land leveling, digging pit, contour terracing, pruning, fertigation, pesticide or nutrients spraying, weeding etc., It has become imperative to expand and fully utilize the potential of cashew to keep pace with growing demand, retain market share and stay ahead in the rapidly emerging competition in the global market. Although India is maintaining the prominent position in the global cashew industry, comparative advantages should be continuously reassessed to remain competitive. In the wake of farm labour scarcity, continuous effort is needed to develop labour saving technologies to supplement labour supply and off-set rising labour costs.

On the other hand, cashewnut processing developed in the last century was labour oriented, employing largely rural women who contributed 90% of the work force and with minimal mechanization. The industry has made strides in twentieth century by developing an efficient processing technology over a period of time. Design of shelling machine should accommodate a mechanism to position nuts precisely so that the shelling blades penetrate and split open exactly in the line connecting two halves of the nut. Moisture conditioning prior to mechanical peeling is the major problem irrespective of various techniques adopted for peeling testa. Single grading machine for cashew kernels accounting all the quality parameters viz., size, surface colour and degree of smoothness can improve the qualitative and quantitative efficiency. Emissions into the air and water in particular will be of more concern and development of highly efficient boilers and CNSL extraction plants will become imperative. Increased competition for labour and advances in mechanization has changed the processing scenario in this country. Facilities provided to labourers in cashew factories may be better now, but are still not attractive for workers having alternatives in newer field due to the improved economy in this country. Investment and capital cost is rising and financial barriers for small and medium level processing is growing. The trend toward the use of technology even in the limited form of cashew processing machines is making new demands from small and medium size cashew processing plants. It is important that managers should enhance knowledge on working with machines and the factors which influence its success or failure. Environmental concerns will impact the cashew industry owing to energy and environmental audit on processing plants. Appropriate mechanization in cashew needs to be accelerated for substantial growth in economic, environment and food security.

2.4. Mechanization and value addition in spice processing

Spices are high value export oriented crops extensively used for flavouring food and beverages, medicines, cosmetics, perfumery etc. Spices constitute a significant and indispensable segment of culinary art and essentially add flavour, colour and taste to the food preparations. India is the largest producer, consumer and exporter of spices in the world. India produces more than 65 spices out of the total 109 spices listed by International Standards Organisation (ISO). India produces around 5.8 million tonnes of spices annually (2012-13), of this about 10% of the total produce is exported to over 150 countries. The USA, Europe, Australia, Japan, the Middle East and Oceanic countries are the major importers of Indian spices. The estimated world trade in spices is 1.05 million tonnes valued at 2750 million US $, out of which India has a significant share of 48% in quantity and 43% in value.

(I) Back pepper

Black pepper takes about 7-8 months after flowering to reach full maturity and is harvested during December-January in plains and from January-April in the high ranges of Western Ghats. It is important to harvest pepper at the proper stage of maturity in order to achieve a dried product of good colour and appearance. Harvesting of pepper begins when one or two berries in the spike turn yellow. The spikes are nipped of by hand and collected in bags (Fig.2.72). Normally, single pole bamboo/aluminium ladder is used as a support for climbing while harvesting. If the berries are allowed to over ripe, there is heavy loss due to berry drop and damage by birds. Spikes which are fallen on to the ground is collected separately, cleaned and then pooled to the general lot.

Fig.2.72: Harvesting of black pepper using aluminum pole

Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity required at harvest for processing into different pepper products is given in Table 2.11.

Table 2.11. Optimum maturity at harvest for different pepper products

Product	Stage maturity at harvest
Canned pepper	4-5 months
Dehydrated green pepper	10-15 days before maturity
Oleoresin and essential oil	15-20 days before maturity
Black pepper	Fully mature and 1-2 berries start turning from yellow to red in each spike
Pepper powder	Fully mature with maximum starch
White pepper	Fully ripe

Post harvest processing

Post harvest processing operations followed for black pepper involves threshing, blanching, drying, cleaning, grading and packaging. During processing care should be taken to maintain the quality during each step of operation.

Threshing

The berries are separated from the spike traditionally by trampling with human legs. This operation is crude, tedious and unhygienic. Chances of extraneous matter, soil particles and filth contaminating the produce are also high. Mechanical threshers with capacities varying from 50 kg/h to 2500 kg//h are available which can thresh quickly and provide cleaner products (Fig.2.73). Considering the shortage of human labour mechanical threshing can be popularized at cluster level.

Fig.2.73: Black pepper thresher

Blanching

The quality of the black pepper obtained can be improved by a simple treatment of dipping the harvested green berries, taken in a perforated vessel, in boiling water for a minute before drying. This processing technique has several advantages:

- Uniform coloured black pepper is obtained after drying.
- Pepper can be dried in 3-4 days as against 5-6 days required when following the traditional practice
- Removes the extraneous impurities like dust and reduces the microbial load of the berries.
- Drying

Freshly harvested green pepper has a moisture content of about 65 to 70% at harvest, which should be brought down to safe level of 10% by adequate drying. The green colour of matured pepper is due to the presence of chlorophyll pigment. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on clean dry concrete floor / bamboo mats/ PVC sheets and dried under sun for 3-5 days to bring the moisture content below 10%. The average dry recovery varies between 33-37% depending on the varieties and cultivars.

Cleaning and grading

The dried black pepper has extraneous matter like dust, spent spikes, pinheads, stones, soil particles etc. mixed with it. Cleaning and grading are basic operations that enhance the value of the produce and help to get higher returns. Cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such units consist of a fan/ blower and a feeding assembly. The fan is placed at the rear end of the hopper. Cleaning is achieved by feeding the

material through the hopper into a stream of air blowing in perpendicular direction. The heavier fractions (dust, immature berries, pin heads and spent spikes) are blown away. Grading of black pepper is done by using sieves (3, 3.5, 3.8 and 4.8 mm etc.) and sifting black pepper into different grades based on size.

Packaging

Organically grown black pepper should be packaged separately and labelled. Mixing different types of pepper is not good from a commercial point of view. Eco friendly packaging materials such as clean gunny bags or paper bags may be adopted and the use of polythene bags may be minimized. Recyclable/ reusable packaging materials shall be used wherever possible.

Storage

Black pepper is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity may result in mould and insect infestation. Before storage, black pepper has to be dried to less than 10% moisture content. The graded produce is bulk packaged separately in woven polypropylene bags or jute bags provided with food grade poly ethylene liners or in or multi layer paper bags. The bags are arranged one over the other on plastic/wooden pallets after laying polypropylene sheets on the floor to reduce the ingress of moisture into the produce.

(II) Cardamom

Cardamom plants start bearing two or three years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120-135 days after its formation. Harvesting period commences from June-July and continues till January-February in Kerala and Tamil Nadu. While in Karnataka, harvesting begins in August and prolongs till December-January. Usually harvesting is done at an interval of 15-30 days.

The capsules are harvested when they attain physiological maturity, which is indicated by dark green colour of rind and black coloured seeds. Harvesting of ripened capsules is avoided as it leads to the loss of green colour and also causes splitting of capsules during curing process. Immature capsules on processing yields uneven sized shriveled and undesirably coloured produce. When a cardamom capsule is fully matured it can be easily removed from the stem of the plant without too much force. The harvester should start harvesting at the base of each stem and move up the stem, taking off any capsules that easily fall off without pulling. The capsules that do not fall off easily should be left on the plant to ripen.

Post harvest processing

Freshly harvested capsules are subjected to post harvest operations like cleaning, alkali treatment, drying, destalking, grading, packaging and storage.

Cleaning

Harvested capsules are washed in water to remove the soil particles and other dirt adhering to it

and this process helps to get good quality finished product.

Pre-treatment

The fresh cardamom capsules are soaked in a solution of sodium bicarbonate (2-5%) for ten minutes to help retain the green colour. A 2% solution of sodium bicarbonate is prepared by dissolving 20 g of sodium bicarbonate in 1 litre of water. The capsules are removed from water and are spread on wire net trays of the drier.

Drying

Drying/curing of cardamom is the process by which moisture content of freshly harvested capsules is reduced from 80-85% to 10% through indirect heating. If the drying period is too long, mould can start to grow on the cardamom. There are several methods available to dry cardamom for the small scale processors, depending upon the size of the business and the local weather conditions. Each method has different advantages and disadvantages:

Cardamom is dried by adopting two methods:

1. Natural (Sun drying)
2. Artificial drying

Natural (Sun drying)

Freshly harvested capsules are directly dried under sun for a period of five to six days or more depending on the availability and duration of sunlight. Natural drying does not retain green colour of capsules and also leads to splitting of the capsules. During cloudy and rainy weather conditions, proper drying of capsules cannot be accomplished and hence the quality of the capsules deteriorates. In general, sun dried capsules are not preferred for export. Sun drying is commonly practiced in some parts of Karnataka.

Artificial drying

It is one of the best methods of drying by which high quality green cardamom can be obtained. A traditional firewood based curing house consists of a furnace for burning the wood, flue pipes for conveying the hot air and drying racks for stacking the trays. A drying chamber with dimensions of 4.5 m in length and breadth is sufficient for a plantation, which has a production capacity of 2 tonnes of fresh cardamom. In general, 3-4 kg of firewood is consumed for drying 1 kg of fresh cardamom.

The capsules are evenly spread as a single layer on the trays. After staking the trays on the racks in the drying chamber, the curing room is closed. Hot air generated by burning firewood in the furnace is circulated through the flue pipes, which are placed few centimeters above the floor. This process enhances the room temperature to 45-55°C, which is maintained for a period of 3-4 hours. During this period, the capsules sweat and give off the moisture. The drying process is facilitated by opening the ventilators for sweeping out the water vapour generated from the drying capsules.

Exhaust fans are also used for the speedy removal of moisture. After complete removal of water vapour, the ventilators are closed and the temperature inside the chamber is again maintained at 45-55oC for a period of 18-24 hours. In the final stage of curing process, the temperature is further raised to 60-65°C for another 1-2 hours. The temperature is raised to hasten the cleaning process by which debris like stalks attached to the capsules can be removed easily. Temperature inside the curing chamber is maintained around 65°C to avoid splitting of the capsules and also to prevent the loss of volatile oil. Under these conditions, it is possible to obtain high quality green cardamom in about 24-30 hours.

Efficient and highly automated cardamom dryers have been developed and being widely used with alternative sources of fuels such as kerosene, Liquid Petroleum Gas (LPG) and diesel or with combination of fuels. Such kind of improved systems have the advantage of retaining high quality of produce with respect to colour and duration of curing is also substantially reduced to 16-18 hours.

Polishing and grading

The dried capsules are rubbed on wire mesh to remove the stalk, dried portion of flower from the capsules and then graded according to size by passing through sieves of sizes of 7, 6.5, 6 mm etc. The graded produce is stored in polythene lined gunny bags to retain the green colour during storage.

Dried capsules are polished either manually or with the help of machines. Polishing is carried out by rubbing the dried capsules in hot state against a hard surface. The polished produce is subsequently graded based on the quality parameters such as colour, weight per volume, size and percentage of empties, malformed, shrivelled and immature capsules.

After grading, cardamom capsules are stored at a moisture content of less than 10% to retain the original parrot green colour and to prevent mould growth. Use of 300 gauge black polythene lined gunny bags improves efficiency of storage. It is advisable to store the dried cardamom in wooden boxes at room temperature, preferably in the curing houses.

(III) Turmeric

Well managed turmeric crop is ready for harvest in seven to nine months depending on the variety and time of sowing. The crop is generally harvested during January to March. On maturity, the leaves turn dry and are light brown to yellowish in colour. In Kerala, turmeric is grown in raised beds prepared either manually or by using a tractor with broad bed former. Harvesting of the matured crop is done either manually or by using a tractor depending upon how the beds were formed. In case of manual harvesting, the land is ploughed, the clumps are carefully lifted with spade and the rhizomes are gathered by hand picking. Harvesting with a tractor attached to a turmeric harvester is followed when the raised beds are taken using a tractor. The harvested rhizomes are collected manually and all the extraneous matter adhering to them is cleared.

Post harvest processing

The harvested turmeric rhizomes before entering into the market is converted into a stable

commodity through a number of post harvest processing operations like boiling, drying and polishing. Boiling of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter takes a little longer to cook. The dry recovery of the different turmeric varieties vary widely ranging from 19 to 23%.

Boiling

Boiling is the first post harvest operation to be performed at the farm level which involves cooking of fresh rhizomes in water until soft before drying. Boiling destroys the vitality of fresh rhizomes, avoids the raw odour, reduces the drying time and yields uniformly coloured product.

In the traditional method, a vessel made of galvanized iron sheet is used for turmeric boiling. Boiling of turmeric rhizomes is carried out till froth forms and white fumes come out of the pan with a characteristic odour. Boiling is considered complete when a pointed stick can penetrate easily in to the rhizomes with slight pressure. The other indications of the completion of boiling process are softness and easy breaking of rhizomes when pressed between the fore finger and thumb and a yellow interior instead of red one. An effective cooking time of 45 to 60 minutes for fingers and 90 minutes for mother rhizomes is considered essential. Overcooking and under cooking are found to affect the quality of the rhizome.

Improved turmeric boiler using steam boiling technique is followed when large quantities of turmeric are to be cured. The Tamil Nadu Agricultural University (TNAU) model of improved steam boiler for turmeric consists of a trough, inner perforated drums and a lid (Fig.2.74). The outer drum is made of 18 SWG thick mild steel to a size of 122 x 122 x 55 cm. A lid is provided with hooks for easy lifting and also provided with an inspection door. For easy draining and cleaning, an outlet is placed at the bottom of the drum. Four numbers of inner drums of 48 x 48 x 45 cm size are provided in the outer drum. The capacity of four inner drum is 100 kg. The inner drums are provided with a leg for a height of 10 cm, so that the rhizomes will not come in contact with water filled for about 6-8 cm depth in the outer drum. The outer drum is placed with more than half of its depth below the ground level by digging a pit, which serves as a furnace. This furnace is provided with two openings, one for feeding the fuel and the other one for removing the ash and unburnt.

Fig.2.74: Turmeric boiler

After placing the turmeric boiler in the furnace, about 75 litres of water is added (6-8 cm depth). About 55-70 kg of well washed rhizome is taken in each inner drum and placed in the boiler and the lid is placed in position. Using the available agricultural waste materials, mostly, the turmeric leaves, fire is put in the furnace. During the boiling process, it takes about 25 minutes to produce steam and boil the initial batch of

Fig.2.75: Large scale turmeric boiler

rhizomes and 10-15 minutes for the subsequent batches. Through the inspection door, the stage of boiling of the rhizome is assessed by pressing the rhizomes with a hard pin / needle.

Using a long pole, the lid is removed and the inner drums are lifted one by one. For the next batch, about 20 litres of water is added to the outer drum, depending on the water lost by evaporation. The next batch of rhizomes is loaded in all the drums and heating is continued. At the end of the boiling process, all the drums need to be cleaned free of mud and soil to avoid damage and enhance the life of the gadget. The capacity of the boiler is about 100 kg per batch and the fuel requirement is 70-75 kg of agricultural waste materials. Turmeric boiling units of capacity 1 tonne/batch is also available and is used in regions where turmeric is grown extensively.

Drying

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor. A thin layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the material should be heaped or covered. It may take 10-12 days for the rhizome to dry completely. The bulbs and fingers are dried separately, the former takes more time to dry. Turmeric should be dried on clean surface to ensure that the product does not get contaminated by extraneous matter. Care should be taken to avoid mould growth on the rhizomes. Rhizomes are turned intermittently to ensure uniformity in drying. The yield of the dry product varies from 20-25% depending upon the variety and the location where the crop is grown. The starch gelatinized during boiling shrink and during the drying process intercellular spaces increase, enhancing water diffusion and reducing the drying time.

Polishing and colouring

Dried turmeric has poor appearance and rough dull outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing. Polishing is done till the recommended polish of 7-8% is achieved. Usually 5 to 8% of the weight of turmeric is the polishing wastage during full polishing and 2 to 3% during half polishing. Polishing of dried turmeric also helps in removing the wrinkles.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. Manual polishing gives rough appearance and dull colour to the dried rhizome. Polishing is done by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal screen. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against each other as they roll inside the drum. The turmeric is also polished in power operated drums (Fig.2.76). Large scale polishing units with capacity to polish 500 to 1000 kg per batch is used for polishing turmeric rhizomes at commercial units. It takes about 45-60

Fig.2.76: Turmeric polisher

minutes per batch and about 4% is wasted as dust. The colour of the processed turmeric influences the price of the produce. Hence to obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

Cleaning, grading, packing, and storage

Although Indian turmeric is considered to be the best in the world, about 90 % of the total produce is consumed internally and only a small portion of the production is exported. Turmeric of commerce is described in three ways:

Fingers: These are the lateral branches or secondary 'daughter' rhizomes which are detached from the central rhizome before curing. Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.

Bulbs: These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers.

Splits: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.

Turmeric being a natural produce, is bound to gather contaminants during various stages of processing. The spice is also cleaned to remove such foreign materials. A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter. Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light. The stores should be clean and free from infestation of pests and harborage of rodents. It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests.

(IV) Ginger

Harvesting of the crop for vegetable purpose starts from the sixth month of planting based on the demand and price of the produce. However, for making dry ginger, the matured rhizomes are harvested after eight months i.e. when the leaves turn yellow and start drying. Irrigation is stopped one month before harvest and the rhizome clumps are lifted carefully with a spade or digging fork. The dry leaves, roots and soil adhering on the rhizomes are manually separated. The mother rhizome has equal market value as that of freshly harvested ginger because of the large size. Late harvest is also practiced, as the crop does not deteriorate by leaving it for some months underground. In India, domestic market prefers fresh green ginger for culinary use while two types of dried ginger i.e. bleached and unbleached are also produced for export purpose.

The most important criteria in assessing the suitability of ginger rhizomes for particular processing purposes are the fibre content, volatile-oil content and the pungency level. The relative abundance of these three components in the fresh rhizome is governed by its state of maturity at harvest. Tender rhizomes lifted at the beginning of the harvesting season, about 5 to 7 months after planting, are preferred for the manufacture of preserved ginger since the fibre content is negligible and the pungency is mild. As the season progresses, the relative abundance of the volatile oil, the pungent

constituents and the fibre increases. At about eight months after planting, the volatile oil and pungent principle contents reach a maximum and thereafter their relative abundance falls as the fibre content continues to increase. In India, the volatile oil content of ginger has been reported to be at maximum between 215 and 260 days after planting.

Post Harvest Processing

Processing of ginger to produce dry ginger basically involves two stages - peeling of the ginger rhizomes to remove the outer skin and sun drying to a safe moisture level.

Peeling

Peeling serves to remove the scaly epidermis and facilitate drying. Peeling of fully matured rhizomes, is done by scrapping with bamboo splits having pointed ends to remove the outer skin and to accelerate the drying process. Deep scraping with knifes should be avoided to prevent the damage of oil bearing cells which are present just below the outer skin. Excessive peeling will result in the reduction of essential oil content of the dried produce. The peeled rhizomes are washed before drying. The dry ginger so obtained is valued for its aroma, flavour and pungency.

Indian dried gingers are usually rough peeled when compared to Jamaican gingers, which are clean peeled. The rhizomes are peeled only on the flat sides and much of the skin in between the fingers remains intact. The dry ginger so produced is known as the rough peeled or unbleached ginger and bulk of the ginger produced in Kerala are of this quality. Sometimes Indian gingers are exported unpeeled.

Drying

The moisture content of ginger after harvest is about 80-82 % which is brought down to 10% for its safe storage. Traditionally ginger is sun dried in a single layer in open yard which takes 7 to10 days for complete drying. The sun dried ginger is brown in colour, with irregular wrinkled surface and when broken, shows a dark brownish colour. The yield of dry ginger is 19-23 % of fresh ginger depending on the variety and climatic zone.

Polishing

Polishing of dried ginger is done to remove the wrinkles developed during drying process. In traditional method, the dried ginger is rubbed against hard surface and this helps to remove the dry scales of the skin attached to the surface.

Bleached ginger

Bleached ginger is produced by dipping scrapped fresh ginger in a slurry of slaked lime, $Ca(OH)_2$, (1 kg of slaked lime / 120 kg of water) followed by sun drying. As the water adhering to the rhizomes dry, the ginger is again dipped in the slurry. This process is repeated until the rhizomes become uniformly white in colour. Dry ginger can also be bleached by the similar process. Liming gives ginger a better appearance and less susceptibility to the attack of insect pests during storage and shipping.

Cleaning and grading

Cleanliness of spices has been the major concern of the importing countries. Once the ginger is cleaned and dried it is graded manually. For ginger, the grading takes into consideration the size of the rhizome, its colour, shape, extraneous matter, the presence of light pieces and the extend of residual lime (in the case of bleached ginger).

Packaging and Storage

Dry ginger, packed in gunny bag, is highly susceptible to insect infestation during warehouse storage. It is preferable to use polythene laminated gunny bags for packaging dried ginger. Dried ginger should be stored ensuring protection from dampness. Dunnage made of PVC/wooden crates should be used to stack the packaged bags to prevent moisture ingress from the floor. Care should be taken to stack the packed bags 50 to 60 cm away from the walls. Insects, rodents, and other animals should be effectively prevented from getting access to the premises where gingers is stored. Prolonged storage of ginger would result in deterioration of its aroma, flavour and pungency.

Organic ginger has to be packaged in reusable and biodegradable packaging material whenever possible and the material should not contaminate the organic food. Organically produced ginger should be labeled accordingly. Packaging materials, storage containers or bins that are contaminated with fungicides, preservatives or fumigants are prohibited to be used for packaging ginger as they are likely to compromise the organic integrity of product.

(IV) Nutmeg

Nutmeg and mace are two different parts of the same fruit of the nutmeg tree, Myristica fragrans. Nutmeg is the dried kernel of the seed and mace is the dried aril surrounding the seed. Both the spices have similar flavour. However, nutmeg is reported to be slightly sweeter than mace and is more preferred in food. Besides dry nutmeg and mace, a number of other valuable products like oleoresins, nutmeg butter and essential oils are also derived from M. fragrans and they find varied uses in the food, medicine and perfume industries.

Nutmeg fruits are harvested when they split open on ripening. The split fruits are either plucked from the tree with a hook bill or are collected soon after they drop onto the ground. Processing of nutmeg starts with the removal of mace surrounding the nut followed by drying of nut and mace separately. In Kerala, as the crop is harvested during monsoon season, sun drying is not possible and most of the farmers adopt traditional methods to dry the harvested nutmeg.

Post harvest processing of nut

Firewood is generally used to dry nutmeg. Nutmeg is spread to a thickness of about 5-8 cm on wooden trays having openings at the bottom for hot air circulation. The trays are placed approximately about 3 m above the furnace and the heat produced by burning firewood is used to dry nutmeg. Burning of firewood for drying is generally done in the evening and left as it is till the

next day. Firewood is loaded into the furnace only once and no further firewood is added. This is followed for five days and by the end of 5th day the nutmeg is completely dry and the seeds inside rattle on shaking.

Hot air mechanical drying at a temperature of 45oC is also followed for drying of nutmeg (Fig.2.77). While using a mechanical drier, care should be taken to see that continuous drying is not followed. Alternate heating and non heating periods are required for complete drying of nutmeg. It is also found that excessive temperature will result in oozing out of nutmeg oil which in turn reduces the quality. Hence, drying of nutmeg at low temperature is mostly preferred. Natural convection reverse air flow driers are also being used by the farmers for drying of nutmeg.

Fig.2.77: Mechanical drier for during nutmeg or mace

Grading of nutmeg

The dried seeds are sorted using the flotation method. Lighter kernels (which are generally unsound) float to the surface of a tank and can be removed. The sound kernels are sorted based on their quality and size. Good quality whole kernels are separated from the lower quality and broken kernels. Nutmegs are graded according to their size. Sizing can be carried out using different mesh sized sieves. Nutmegs, weighing about 8g or more are considered to be superior and are traded at a higher price.

Grades of nutmeg

Whole nutmegs are grouped under three broad quality classifications:

Sound: Nutmegs which are mainly used for grinding and to a lesser extent for oleoresin extraction. High quality or sound whole nutmegs are traded in grades which refer to their size in numbers of nutmegs per pound: 80s, 110s and 130s (110 to 287 nuts per kg), or 'ABCD' which is an assortment of various sizes.

Substandard: Nutmegs which are used for grinding, oleoresin extraction and essential oil distillation. Substandard nutmegs are traded as 'sound, shrivelled' which in general have a higher volatile oil content than mature sound nutmegs and are used for grinding, oleoresin extraction and oil distillation; and 'BWP' (broken, wormy and punky) which are mainly used for grinding as volatile oil content generally does not exceed 8%.

Distilling: Nutmegs of poor quality are used for essential oil distillation. Distilling grades of nutmegs are: 'BIA' or 'ETEZ' with a volatile oil content of 8% to 10%; and 'BSL' or 'AZWI' which has less shell material and a volatile oil content of 12% to 13%.

Metal sieve grading

Using large metal sieves with uniform regular circular perforations and sieves of different sizes,

workers pour on hand-graded sounds and gently massage them. The appropriate kernels fall through the appropriate holes into collecting bags.

Packaging and storage of nutmeg

Sorted kernels are bagged and labelled appropriately. They are usually packed into Hessian sacks or gunny bags. If other packing materials are used, care must be taken to avoid materials which might lead to 'sweating' and mould development. Packaging should be such that the maximum weight loss is 10%. Spices must be dried thoroughly prior to shipment. The maximum limits for moisture as per ASTA specifications for whole and ground nutmeg is 8%. Nutmegs are usually sold whole, either with or without the shell. Ground nutmeg is also available, but this is generally of inferior quality and can easily be adulterated. The taste and aroma of ground nutmeg deteriorate very rapidly. Dried whole nutmegs have a long shelf life if they are stored in a dry place away from sunlight and insect infestation.

Post harvest processing of mace

Drying of mace to an optimum moisture level without losing the inherent qualities especially colour is a pre-requisite for long storage and better price. Colour plays an important role in deciding the commercial value of mace and that its scarlet red colour is due to the presence of the pigment lycopene. This pigment is highly sensitive to heat and light. During drying, scarlet-red colour of mace changes to light red or reddish brown colour.

Conventionally, mace is dried in the sun or in the kitchen fireplace utilising the heat from the stove. Some farmers dry mace on clay 'kurdis' or sand medium spread over iron sheet which is kept over fire. In these conventional methods, it is difficult to control the temperature of drying, which has profound influence on the colour of the mace. The dried mace so obtained does not possess uniform red colour. Also, about 2-3% of the mace gets charred in the process. Sun drying is difficult and very slow in many areas because of the active monsoon during the harvesting season. Improved drying unit have been developed by farmers using tiled hollow bricks laid over the chulas. Required quantity of firewood is burnt and mace is dried without charring.

Fig.2.78: Fire wood operated drier for mace or nutmeg drying

Hot air mechanical drying is a viable alternate technology for curing mace. A mild blanching and subsequent drying of mace at 50oC in a cross flow dryer helped in retention of colour and general quality of mace. Natural convection reverse air flow driers are used by the farmers and cottage scale industrial units for drying of mace (Fig.2.78).

Grading of mace

As per the 'Agmark' Mace Grading Marking Rules (1997), the standard grade mace of India should be the dried, flattened aril of the ripe fruit of nutmeg tree, Myristica fragrans and be free from aril

of other variety of Myristica malabarica and Myristica agrentia (wild mace). It should be of buff of light brown colour, horny and brittle.

(V) Cinnamon

Cinnamon (Cinnamomum zeylanicum) is obtained by drying the central part of the bark after the second or third year of planting. It is harvested from the branches which have attained greenish brown colour indicative of maturity and when the bark peels of easily. The shoots are cut for bark extraction.

Post harvest processing

Following are the stages in the production of quills:

Peeling

The rough outer bark is first scraped off with a special knife. Then the scraped portion is polished with a brass rod to facilitate easy peeling. A longitudinal slit is made from one end to other and the bark is peeled off (Fig.2.79).

Fig.2.79: Peeling of cinnamon using hand knife

Rolling

The barks are packed together and placed one above the other and pressed well. The bark slips are reduced to 20 cm length and are piled up in small enclosures made by sticks. Then they are covered with dry leaves or mat to preserve the moisture for the next day's operation and also to enhance slight fermentation.

Piping

Rolled slips are taken to the piping yard for piping operations. The outer skin is scraped off with a small curved knife. The scraped slips are sorted into different grades according to thickness. The graded slips are trimmed; ends are cut and pressed over pipes. Slips are rolled into pipes and soon after they are allowed to dry. During drying, smaller quills are inserted into the bigger ones, forming smooth and pale brown compound quills, which are known as pipes. The quills are arranged in parallel lines in the shade for drying, as direct exposure to the sun at this stage would result in warping. The dried quills, thus obtained, consist of a mixture of coarse and fine types and are yellowish brown in colour. The quills are bleached, if necessary, by sulphur treatment for about 8 hours.

The process of producing quills has several by-products, which are used in further processing:

Quillings: These are broken pieces of quills used mainly for grinding but also for distillation of oil. The pieces vary considerably in size, being about 5 to 15 or 20 cm in length and about 10-25 mm in diameter.

Feathering: These are short shavings and small pieces of leftovers in the processing of the inner bark into quills. Collectively, featherings present a shade darker colour than the quills and a shade lighter than the chips.

Chips: These are small pieces of bark, grayish brown on the outer side and a lighter brown on the inside. They are deficient in both aroma and taste and are not to be compared to the quills for flavour.

(VII) Clove

Clove is the small, reddish brown unopened flower bud of the tropical evergreen tree Syzygium aromaticum. The trees begin to yield from 7-8 years after planting. Buds are harvested when the base of calyx has turned from green to pink in colour. If allowed to develop beyond this stage, the buds open, petals drop and an inferior quality spice is obtained on drying.

Post harvest processing

Prior to drying, buds are removed from the stem by holding the cluster in one hand and pressing it against the palm of the other with a slight twisting movement. The clove buds and stems are piled separately for drying. Buds may be sorted to remove over-ripe cloves and fallen flowers. Immediately after the buds are separated from the clusters, partial shade drying is followed. In sunny weather, drying is completed in 4-5 days giving a bright coloured dried spice of attractive appearance. During drying, clove loses about two-third of its original fresh green weight. When properly dried, it will turn bright brown and does not bend when pressed. The dried cloves are sorted to remove mother of cloves and khoker cloves, bagged and stored in a dry place.

(VIII) Chillies

Chilli is the dried ripe fruit of genus "capsicum" which is also called red pepper and it constitutes an important commercial crop used as a condiment, culinary supplement or as a vegetable. Among the chilli consumed in India, dried chilli contributes the major share. The Indian sannam variety of chilli is well known the world over. It is cultivated in Andhra Pradesh and part of Tamil Nadu. The main marketing season for chilli in India is February-March.

Post harvest processing

Harvesting of chillies is done when the pods are well ripened and partially withered in the plant itself. Immediately after harvesting of fresh fruits, they are heaped indoors for 2 or 3 days, so that the partially ripe fruits, if any, are ripen fully and whole produce develops a uniform red colour. The best temperature for ripening is 22-25°C and direct sun light should be avoided which can cause development of white patches.

Drying

The drying of chilli is done by spreading the fruits on dry ground or concrete floor under sun. In case of cement floor, drying takes 5-6 days for the reduction of moisture content from 65-70%

to 10%, while in mud floor it takes 3-4 days during sunny days. In case of cloudy weather and intermittent rains, damages as high as 50% are reported. Such unfavourable conditions also lead to discolouration with white spots over the surface of final product. Loss of glossiness and pungency are also noticed. In view of its direct exposure to environment, dirt may also get deposited on the chilli besides; this method involves excessive handling and irrecoverable shatter loss.

Sorting

At the final stage of drying, the discoloured, spoiled and other damaged ones are manually sorted based on the eye judgment and experience. These sorted ones are collected and separated. This amount to 4-5 quintals of dry chilli obtained in a crop area of one hectare. This works out to about 20 to 25% of the final produce. This reject is sold separately at a much lower price. During the sorting process itself the dried chilli fruits will be windrowed for easy collection and packaging.

Destalking

Destalking of dried chilli pod is done after drying and before cold storage/marketing. The export lots are preferred without stalk as required by the buyers. Contract women labour are engaged for destalking. Normally a woman can destalk 12-15 kg of chili. The chilli stalks after removal has no commercial value and hence burnt or composted.

Collection and heaping

The dried chilli are collected from the drying yard in polywoven bags and transported to the packing yard and heaped. Being a high volume material, during heaping, compaction is done to accommodate more quantity in less space. To prevent absorption of moisture from the atmosphere, the heap is also fully covered with polythene sheets till packed in bags and transported to the market.

Packaging

The well-dried chilli pods are packed in gunny bags for transporting to the market. Normally the gunny bags will hold about 30 kg of dried chilli and to accommodate more quantity of chilli in each bag, the material being packed is compacted. For compacting the produce, manually it is rammed in the gunny bag by a labour. By this, about 50 kg of dry chilli is packaged in a gunny bag. This helps to reduce bulk and in easy transportation.

Cold Storage

To maintain the quality and preserve the colour of dried chilli packed in gunny bags is stored under cold storage. More than 60 cold storage godowns are available in and around Guntur, Andhra Pradesh state and also few units available in Tamil Nadu state. Normally the storage will be for the period during February to December. Storage is done at a temperature of 4-6□C and the relative humidity ranges 60 to 80%. The cold storages are normally with a plinth area of 1000 to 2000 m2 with 4-6 floors. Each floor is to a height of 3-4 m and the evaporators are placed in the each floor for uniform distribution of temperature. The bottom of each floor is made of wooden planks and

only steps are used to reach the various levels of the storage godown. The walls and roof of the cold storage godowns are constructed with brick and concrete. The latest ones are constructed with polyurethane foam lined with metal sheet with improved insulation.

CHAPTER 3

PACKAGING OF SPICES AND PLANTATION CROP PRODUCTS

Packaging technology can be of strategic importance to a company, as it can be a key to competitive advantage in the food industry. Consumer demand for pre-packaged food continues to increase in advanced economies and a growing global population is also fuelling the demand. This is also increasingly the case in developing countries experiencing rapid urbanization.

The principal roles of food packaging are to protect food products from outside influences and damage, to contain the food, and to provide consumers with ingredient and nutritional information. Traceability, convenience, and tamper indication are secondary functions of increasing importance. The goal of food packaging is to contain food in a cost-effective way that satisfies industry requirements and consumer desires, maintains food safety, and minimizes environmental impact.

Package design and construction play a significant role in determining the shelf life of a food product. The right selection of packaging materials and technologies maintains product quality and freshness during distribution and storage. Materials that have traditionally been used in food packaging include glass, metals (aluminum, foils and laminates, tinplate, and tin-free steel), paper and paperboards, and plastics. Moreover, a wider variety of plastics have been introduced in both rigid and flexible forms. Today's food packages often combine several materials to exploit each material's functional or aesthetic properties.

3.1. Functional Characteristics of Packaging Materials

Glass: Glass has an extremely long history in food packaging. Glass containers used in food packaging are often surface-coated to provide lubrication in the production line and eliminate scratching or surface abrasion and line jams. Because it is odorless and chemically inert with virtually all food products, glass has several advantages for food-packaging applications: It is impermeable to gases and vapors, so it maintains product freshness for a long period of time without impairing taste or flavor. The ability to withstand high processing temperatures makes glass useful for heat sterilization of both low- acid and high-acid foods. The transparency of glass allows consumers

to see the product, yet variations in glass color can protect light-sensitive contents. Finally, glass packaging benefits the environment because it is reusable and recyclable. Like any material, glass has some disadvantages. Despite efforts to use thinner glass, its heavy weight adds to transportation costs. Another concern is its brittleness and susceptibility to breakage from internal pressure, impact, or thermal shock.

Metal: Metal is the most versatile of all packaging forms. It offers a combination of excellent physical protection and barrier properties, formability and decorative potential, recyclability, and consumer acceptance. The two metals most predominantly used in packaging are aluminum and steel.

Aluminium: Commonly used to make cans, foil, and laminated paper or plastic packaging. Unlike many metals, aluminum is highly resistant to most forms of corrosion. Besides providing an excellent barrier to moisture, air, odors, light, and microorganisms, aluminum has good flexibility and surface resilience, excellent malleability and formability, and outstanding embossing potential. Pure aluminum is used for light packaging of primarily soft-drink cans, pet food, seafood, and pre-threaded closures. The main disadvantages of aluminum are its high cost compared to other metals (for example, steel). Aluminum foil is available in a wide range of thicknesses, with thinner foils used to wrap food and thicker foils used for trays. Like all aluminum packaging, foil provides an excellent barrier to moisture, air, odors, light, and microorganisms. It is inert to acidic foods and does not require lacquer or other protection.

Laminates and metalized films: Lamination of packaging involves the binding of aluminum foil to paper or plastic film to improve barrier properties. Because laminated aluminum is relatively expensive, it is typically used to package high value foods such as dried soups, herbs, and spices. A less expensive alternative to laminated packaging is metallized film. Metallized films are plastics containing a thin layer of aluminum metal. These films have improved barrier properties to moisture, oils, air, and odors, and the highly reflective surface of the aluminum is attractive to consumers. They are more flexible than laminated films and mainly used to package snacks.

Tinplate: In addition to its excellent barrier properties to gases, water vapor, light, and odors, tinplate can be heat-treated and sealed hermetically, making it suitable for sterile products. Although tin provides steel with some corrosion resistance, tinplate containers are often lacquered to provide an inert barrier between the metal and the food product. Like tinplate, tin-free steel has good formability and strength, but it is marginally less expensive than tinplate. Food cans, can ends, trays, bottle caps, and closures can all be made from tin-free steel. In addition, it can also be used to make large containers (such as drums) for bulk sale and bulk storage of ingredients or finished goods.

Plastics: Thermoplastics are ideal for food packaging applications as they can easily be shaped and molded into various products such as bottles, jugs, and plastic films. Polyethylene (PE) and polypropylene are two most widely used plastics in food packaging. There are two basic categories of polyethylene: high density and low density. High-density polyethylene (HDPE) is stiff, strong,

tough, resistant to chemicals and moisture, permeable to gas, easy to process, and easy to form. It is used to make bottles for milk, juice, and water; cereal box liners; margarine tubs; and grocery, trash, and retail bags. Low-density polyethylene (LDPE) is flexible, strong, tough, easy to seal, and resistant to moisture. Because low-density polyethylene is relatively transparent, it is predominately used in film applications and in applications where heat sealing is necessary. Bread and frozen food bags, flexible lids, and squeezable food bottles are examples of low-density polyethylene. Harder, denser, and more transparent than polyethylene, polypropylene (PP) has good resistance to chemicals and is effective at barring water vapor. Its high melting point (160 □C) makes it suitable for applications where thermal resistance is required, such as hot-filled and microwavable packaging. Popular uses include yogurt containers and margarine tubs. When used in combination with an oxygen barrier such as ethylene vinyl alcohol or polyvinylidene chloride, polypropylene provides the strength and moisture barrier for catsup and salad dressing bottles. The most commonly used polyester in food packaging is Polyethylene terephthalate (PET or PETE). PET provides a good barrier to gases (oxygen and carbon dioxide) and moisture. It also has good resistance to heat, mineral oils, solvents, and acids, but not to bases. Consequently, PET is becoming the packaging material of choice for many food products, particularly beverages and mineral waters. The use of PET to make plastic bottles for carbonated drinks is increasing steadily. The main reasons for its popularity are its glass-like transparency, adequate gas barrier for retention of carbonation, light weight, and shatter resistance. The three major packaging applications of PET are containers (bottles, jars, and tubs), semirigid sheets for thermoforming (trays and blisters), and thin-oriented films (bags and snack food wrappers). Polyethylene naphthalate's (PEN) barrier properties for carbon dioxide, oxygen, and water vapor are superior to those of PET, and PEN provides better performance at high temperatures, allowing hot refills, rewashing, and reuse. However, PEN costs 3 to 4 times more than PET. Because PEN provides protection against transfer of flavors and odors, it is well suited for manufacturing bottles for beverages such as beer. Polyvinyl chloride (PVC) has excellent resistance to chemicals (acids and bases), grease, and oil; good flow characteristics; and stable electrical properties. Although PVC is primarily used in medical and other nonfood applications, its food uses include bottles and packaging films. Polyvinylidene chloride (PVdC) is heat sealable and serves as an excellent barrier to water vapor, gases, and fatty and oily products. It is used in flexible packaging as a monolayer film, a coating, or part of a co-extruded product. Major applications include packaging of poultry, cured meats, cheese, snack foods, tea, coffee, and confectionary. It is also used in hot filling, retorting, low-temperature storage, and modified atmosphere packaging. Apart from the above, plastic materials such as polystyrene (PS), polyamide (PA) or nylon, ethylene vinyl acetate (EVA) and ethylene vinyl alcohol (EVOH) are also used in food packaging. Typical applications of polystyrene include protective packaging such as egg cartons, containers, disposable plastic silverware, lids, cups, plates, bottles, and food trays. The properties of major packaging resins used for fresh and processed food products are given in Table 3.1.

Table 3.1: Properties of major packaging resins used for fresh and processed food products

Resin	WVTR	OTR	TES	TRS	IS	Haze	LT	HSTR	Characteristics
PVC	1.5-5	8-25	9-45	400-700	180-290	1-2	90	135-170	Moisture impermeable; resistant to chemicals
PVdC	0.5-1	2-4	55-110	10-19	-	1-5	90	120-150	Vapor barrier; high hardness; abrasion resistant
PP	5-12	2000-4500	35.8	340	43	3	80	93-150	Clear, readily processed
HDPE	7-10	1600-2000	38.2	200-350	373	3	-	135-155	Used for structure
LDPE	10-20	6500-8500	11.6	100-200	375	5-10	65	120-177	Lidding film use; high strength, low cost sealant
LLDPE	15.5-18.5	200	7-135	150-900	200	6-13	-	104-170	Superior hot tack; poor sealing through grease
EVA	40-60	12500	14-21	40-200	45	2-10	55-75	66-177	4% improves heat sealability; 8% increases toughness and elasticity
EVOH	1000	0.5	8-12	400-600	-	1-2	90	177-205	Vapor barrier
PA	300-400	50-75	81	15-30	50-60	1.5	88	120-177	High heat and abrasion resistance, clear, easily thermoformed; printable
PET	15-20	100-150	159	20-100	100	2	88	135-177	Polyester from terephthalic acid reaction with ethylene glycol; abrasion and chemical resistant; structure use
PS	70-150	4500-6000	45.1	2-15	59	1	92	121-177	High impact PS (HIPS) for multilayer sheet extrusion; strong; structure use

All measurements were taken on 25.4 µ thickness film.

WVTR –Water vapor transmission rate, g/m2/24h; OTR-Oxygen transmission rate, cc/m2/24h;

TES – Tensile strength, MPa; TRS – Tear strength, g/mL; IS – Impact strength, J/m; Haze, %; LT – Light transmission, %; HSTR – Heat seal temperature range, oC.

Paper and paperboards: The use of paper and paperboards for food packaging dates back to the 17th century with accelerated usage in the later part of the 19th century. Paper and paperboards are commonly used in corrugated boxes, milk cartons, folding cartons, bags and sacks, and wrapping paper. Tissue paper, paper plates, and cups are other examples of paper and paperboard products. When used as primary packaging (that is, in contact with food), paper is almost always treated, coated, laminated, or impregnated with materials such as waxes, resins, or lacquers to improve functional and protective properties. Kraft paper (used to package flour, sugar, and dried fruits and vegetables), sulfite paper (used to make small bags or wrappers for packaging biscuits and confectionary), grease proof paper (used to wrap snack foods, cookies, candy bars, and other oily foods), glassine (used as a liner for biscuits, cooking fats, fast foods, and baked goods), parchment paper (used to package fats such as butter and lard) and laminated paper (used to package dried products such as soups, herbs, and spices) are different types of papers commonly used in food packaging. Paperboard is thicker than paper with a higher weight per unit area and often made in multiple layers. It is commonly used to make containers for shipping—such as boxes, cartons, and trays—and seldom used for direct food contact.

Biobased Packaging Materials: In recent years, much research has been carried out on biodegradable polymers as potential packaging materials in order to reduce the environmental pollution caused by plastic wastes. Biodegradable polymers such as starch, cellulose, gluten, chitin/chitosan, whey/soy protein concentrate, polylactic acid (PLA), hydroxyl propyl methyl cellulose (HPMC), polybutylene adipate co-terephthalate (PBAT), poly hydroxy alkanoate (PHA), poly hydroxy butyrate (PHB) and polycaprolactone (PCL) have attracted considerable attention in the packaging industry.

3.2. Special Packaging systems

Objectives: delay deterioration and extend shelf life of food, maintain quality

Modified atmosphere packaging, controlled atmosphere packaging, vacuum packaging, gas packaging, hypobaric storage, aseptic packaging

Modified Atmosphere Packaging (MAP)

It is enclosure of food in a package in which the atmosphere (gaseous composition) surrounding the food is modified or altered to give optimum atmosphere for extension of shelf life (by 40-50%) and maintaining quality of food.

MAP is normally used in combination with low temperature

Type of MAP

1. Active MAP (active modification): It involves displacing the air with a controlled, desired mixture of gases (gas flushing).

Active packaging is also sometimes referred to as Active MAP, whereby an active substance is used to perform some active role. For example, an O2 adsorber, e.g. ferrous carbonate is used to adsorb O2.

Method:

i. Vacuumizing

ii. Vacuumizing followed by gas flushing

iii. Injecting gas without vacuumizing

Equipment:

i. Form-fill-seal

ii. Chamber method (filling → vacuumizing → gas flushing → sealing)

iii. Snorkel machine (continuous process, similar operation as chamber method)

2. Passive MAP (passive modification): an atmosphere high in CO2 and low in O2 occurs as a consequence of the food's respiration or the metabolism of microorganisms associated with the food over time.

The package film permeability is such that O2 can enter the package to avoid anoxic condition and anaerobic respiration at the same time excess CO2 can diffuse from the package (avoids injurious effect).

Controlled Atmosphere packaging CAP

In CAP, the atmosphere inside the package is continuously monitored and adjusted to maintain the optimum composition within quite close tolerances (so called controlled atmosphere). In strict sense, CAP is enclosure of food in a gas impermeable package, the gaseous composition inside which with respect to CO2, O2, N2, water vapour etc has been changed to increase the shelf life of food.

- Normally bulk packaging and storage
- Normally fruits and vegetables, and fresh produce

Vacuum packaging

Sometimes considered as active MAP method.

Package, normally retail package, evacuated mechanically (vacuum pump), and the food is held in air free atmosphere.

- package is skin-tight
- longer shelf life in oxygen free system
- Normally applied to meat, fish, poultry, cheese
- Suitable packaging materials: PVDC, EVOH (v. low GTR). Nylon may be used in laminate

Method: batch and continuous process

Gas packaging

Package is first evacuated, and then filled with inert gases, CO2 or N2

- Package is devoid of O2, provides protection to food against O2, packaging of oxygen sensitive products, viz. milk powder
- Provides protection from compressive impact; packaging of fragile food, viz. Potato wafer & chips;
- Production of pillow pouch
- Suitable packaging materials: PVDC, EVOH. Nylon may be used in laminate

Hypobaric storage

It is a storage system (structure) for the storage of food in an environment of precisely controlled air pressure, temperature and humidity, and the rate at which air is changed is closely regulated. Air pressure (which is proportional to O2 concentration) is the most important parameter, and it is closely monitored and regulated.

Aseptic packaging

It refers to filling food in package in contamination free (asepsis/sterile) condition.

- Production of pillow pouch
- Most cases: filling pre-sterilized food in sterilized container under sterile environment
- Rare case: filing non-sterile product (yoghurt and similar products) in sterile container under aseptic condition

Method:

- Production of pillow pouch
- Product sterilization by heat. Heat exchangers: tubular, plate, scrap film
- Sterilization of packaging materials by irradiation, heat (superheated steam, saturated steam or hot air) and chemicals (H2O2), in singles or combination
- Sterilization of packaging atmosphere by superheated steam

Advantages:

i. Application of HTST process - efficient heat transfer, superior product quality (nutritional, sensory)

ii. Filling irrespective of container size

iii. Product is shelf stable at normal temperature

Packaging materials:

- Packaging materials: metal, glass, plastic or laminate (PE/paper board/PE/foil/PE)
- Package type: carton, can, bottle, bag, pouch, sachet, cup filling in pouch, sachet and carton is by form-fill-seal system

Active packaging

Packaging is termed as active packaging when it performs an active role (inhibition of microbiological, biological, chemical reactions) besides providing an inert barrier to external environment. The effect is obtained by introducing materials having definite functions into the packaging or other special techniques. The active substances act by adsorption, absorption and reaction. It is that packaging technique that dynamically changes permeation properties or the concentration of different volatiles and gases in the package headspace during storage. AP is mostly applied to plastic packaging.

Oxygen scavenging

Oxygen scavengers/oxygen adsorbers: iron, oxygen scavenging enzymes, ascorbic acid, light activated scavenger, oxygen scavenging reaction system

CO_2 scavenging or scrubbing

i. Absorption of CO_2 in hydrated lime or activated carbon. Calcium hydroxide reacts with CO_2 under high humidity condition and produces $CaCO_3$.

ii. The scavenger, CaO is packed in a porous envelope and put in a sachet containing hydrating agent like silica gel. Water is absorbed by the hydrating agent and CaO reacts with CO_2.

Edible film packaging

An edible film or coating is simply defined as a thin continuous layer of edible material formed on, [placed on, or between the foods, which can be eaten as a part of the whole food product. Selection of material for use in edible packaging is based on its properties to act as barrier to moisture and gases, mechanical strength, physical properties, and resistance to microbial growth. The types of materials used for edible packaging include lipids, protein and polysaccharides or a combination of any two or all of these. The most common form of coating is wax coating to retard respiration, dehydration and senescence. Edible films selected should meet the requirements such as physiochemical and microbial stability, good sensory qualities, high carrier and mechanical efficiencies, free to toxic and safe for health, simple technology, non polluting and low cost of material and process.

Shrink wrap/Individual seal packaging

Individual seal packaging involves the use of heat that shrinkable film (usually HDPE) that is wrapped around the individual units and shrink by blowing hot air over the package. Advantages of

this packaging are ripening is delayed by micro atmosphere created around the product. The films act as a good barrier to water. Prevents the spread of disease from one product to another, improve the handling and sanitation of the product, and facilitates pricing and labeling of individual may occurs with result in poor gas exchange and odors.

Tetra packaging

Tetra packaging materials has 4- 6 layers-

- Polyethylene to protect against outside moisture
- Paperboard for stability and strength
- Polyethylene acts as adhesion layer
- Aluminium foil as a barrier for oxygen, flavor and light
- Polyethylene, again as adhesion layer
- Food grade polyethylene which seals in the liquid

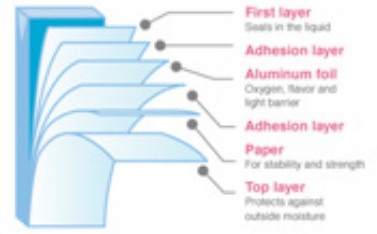


Fig. 3.1: Tetra Packaging layer

UHT process

Pasteurization effectively eliminates potential pathogenic microorganisms and sterilization refers to the complete elimination of all microorganisms. The basis of UHT, or ultra-high temperature, is the sterilization of food before packaging, then filling into pre-sterilized containers in a sterile atmosphere. Juice is processed in this way using temperatures exceeding 135° C, permits a decrease in the necessary holding time (to 2-5 s) enabling a continuous flow operation.

Some examples of other food products processed with UHT are:

- liquid products - milk, juices, cream, yoghurt, wine, salad dressings
- foods with discrete particles - baby foods; tomato products; fruits and vegetables juices; soups
- larger particles - stews

3.3. Packaging specifications of spices: ground and whole

Spices constitute a major part of agricultural commodities and are used to impart flavour and taste to food products. Some spices are not only used in food preparation but finds its use in other industries such as cosmetics, ayurvedic medicines, and perfumery. India is a major producer of spices and contributes 75% of global production, of which ginger, chilli, garlic, small cardamom, coriander and cumin are majorly exported. Due to improper handling and packaging, only 6-7% are exported. To prevent the loss of spices produced, much attention should be given to primary processing and packaging material. Packaging of spices includes identifying the material that helps in preventing moisture migration and retaining the pungency intact. In India, spices are sold in whole and ground form.

The forms of spices in the Indian markets include, whole spices (cardamom, clove, black pepper,

turmeric, ginger, cinnamon), seed spices (fennel, fenugreek, cumin), powdered spices (turmeric, ginger, pepper, chilli), spice mixes, paste (ginger-garlic paste, curry paste), concentrates (tamarind paste), and spice oils and oleoresins. The widely used packaging methods to store and transport spices include bulk packaging (10 to 70 kg), institutional packaging (2 to 10kg), unit or consumer packaging, flexible packaging and rigid glass containers.

Spoilage Factors

In order to select a suitable packaging material/type of package for spices, it is essential to know the factors which affect the quality of spices.

Moisture Content

Spices, specifically spices in powder form, are hygroscopic in nature and pick-up moisture from the atmosphere resulting in sogginess and caking/lumping of the powder. Pick-up of moisture also results in loss of free-flowing nature of the spice powder.

Loss of Aroma / Flavour

Spices contain volatile oils, which impart the characteristic aroma/flavour to the product. Loss in the volatile oil content or oxidation of some aromatic compounds result in aroma and flavour loss.

Discolouration

Some of the spices like green cardamom, red chillies, turmeric, saffron contain natural pigments. Light can affect the pigments resulting in loss or fading of colour and deterioration.

Insect Infestation

Spices are prone to spoilage due to insect infestation, which can be further accelerated due to high humidity, heat and oxygen.

Microbial Contamination

In high humidity condition of 65% and above, moisture absorption occurs. Beyond a certain level of moisture content, spoilage due to microbial growth sets in.

Packaging Requirements

In order to maintain the quality of the spices during handling, transportation, storage and distribution, the packaging material to be used is to be selected with care, keeping in mind the functional as well as the marketing requirements. The packaging requirements for spices, in general, are listed below:

- To protect the product from spillage and spoilage.
- To provide protection against atmospheric factors such as light, heat, humidity and oxygen. The selected packaging materials should have high water vapour and oxygen barriers.

- The packaging material should have a high barrier property to prevent aroma/flavour losses and ingress of external odour.
- The volatile oil present in the spice product has a tendency to react with the inner/ contact layer of the packaging material, at times leading to a greasy and messy package
- With smudging of the printed matter. The packaging material should therefore be grease and oil resistant and compatible with the product.
- Besides the above functional requirements, the packaging material should have good machinability, printability and it should be easily available and disposable.

Packaging of Whole spices

The whole spices are robust and deteriorate slowly compared to the ground spices. Size reduction of spices result in chemical and microbiological changes in the spices that reduces its market value. Whole spices are packed using conventional methods, which is, using gunny bags or twills and are sold in bulk quantities. The weave clearance of A twill, B twill and gunny bags is 1 to 2%, 3-5% and 4-6% respectively. This aids in reducing spillage and insect movement into the bags. Double bags are also used to increase the resistance caused by physical barrier such as polyethylene lined gunny bags and HDPE woven sacks to control moisture migration on storage. Sacks made from 0.03–0.15 mm HDPE have a high tear strength, tensile strength, penetration resistance and seal strength. They are waterproof and chemically resistant and are used instead of multi-wall paper sacks for shipping containers. Now a days, multi-wall paper bags, plastic sacks and paperboard bags are used to store whole spices.

Different type of bulk packaging material used in spice Industry

Jumbo bags FIBC (Flexible Intermediate Bulk Containers) are also used to pack bulk spices. It is made of plastic fiber woven together to form a bag with inner lining of polythene.

The latest trend is to use Jumbo bags (Flexible Intermediate Bulk Containers) (FIBCs) for export of spices. These bags have a capacity of up to 1 tonne and offer various advantages such as:

- Bags are flexible, collapsible and durable
- Can be used for packaging of granules, powder, flakes and any free flowing material
- Product wastage / spillage and tampering can be avoided
- Since the handling is mechanised, less labour is required
- Saving in time for loading and unloading
- Bags are light in weight and, therefore, freight costs are reduced
- Creates eco-friendly, pollution free working atmosphere

The jumbo bags are sometimes made from cloth but mainly from plastic fabric, which can be laminated or provided with an inner plastic liner bag. The bags are provided with filling and discharge spouts and slings for hanging during loading/unloading operations. For designing a jumbo bag, factors such as capacity, product protection requirement, bulk density of the product, filling and discharge facilities available at the user's end, are to be considered.

Example of packaging of whole spices

Black pepper: Double gunny bags are used to pack whole pepper.

Garlic: Harvested garlic is sold in bulk form using open mesh bags.

Carraway: Whole spice is packed in clean, dry jute bags, cloth bags, polyethylene or polypropylene pouches. It is packed in multiples of 500g as per Packed Commodities Rules 1977.

Mace: Packed in cloth bags laminated with polyethylene or polypropylene or pouches made of food grade plastic materials.

Cinnamon: Rolled cinnamon are stacked and arranged in corrugated boxes.

Cumin: Aluminium and polyethylene pouches can be used to store cumin to maintain its sensory qualities and volatile oils.

Nutmeg: It is sold in high barrier packaging material bags to retain its quality and composition. It is sold as whole spics as size reduction leads to deterioration of the volatiles present in it. Nutmeg is also sold in opaque glass containers to restrict odour development.

Institutional Packages

The spice traders also use institutional packs of capacities ranging from 2kg to 10kg. The variety of packages used include laminated flexible pouches and plastic woven sacks which replace traditional

material like tinplate containers and jute bags.

Consumer Packages

The options available to the traders/exporters of spices in the selection of a consumer pack for domestic and export market are quite wide. However, the selection/choice of the packaging material/system depends upon a number of factors, which are broadly listed below:

- Shelf-life period i.e. the degree of protection required by the product against moisture pick-up, aroma retention, discolouration etc. (this is more critical in case of powdered spices)
- Climatic conditions during storage, transportation and distribution
- Type/sector of market
- Consumer preferences
- Printability and aesthetic appeal

The package types generally used as consumer packs are:

- Glass bottles of various sizes and shapes with labels and provided with metal or plastic caps. The plastic caps have added inbuilt features of tamper evidence, dispensing, grinding etc.
- Printed tinplate container with/without dispensing systems
- Composite containers with dispensers
- Plastic containers with plugs and caps with dispensing and tamper evidence features
- Printed flexible pouches – pillow pouch, gusseted pouch, stand-up pouch.
- Lined cartons

Packaging of Ground Spices

Coriander: Coriander is stored for 6 months in Al foil bags while jute bags lined with polythene are suitable for bulk packaging of coriander powder. Paper, polythene and cotton bags are not suitable for packaging as it results in movement of oxygen from the environment which eventually leads to deterioration of the product which is proportional to the surface area exposed to the immediate environment. Coriander seeds are stored in polythene and cotton bags for minimum of 12 month after which loss 20-25% of volatiles incur. Flexible materials such as laminates and foils can be used to reduce loss of volatile oil, fat and moisture ingression. The seeds after packing are to be stored in dry, cool and dark place so as to retard browning reactions. Proper storage environment and packaging material can prove effective up to 6 to 9 months with no loss in flavour and colour.

Garlic: Garlic products such as garlic flakes, dehydrated garlic powder, garlic paste and minced garlic are sold in Al foil pouches and glass containers. Flexible packing of garlic products is done using vacuum packing methods.

Mixed masala powders: These are packed in clean materials made of jute or cloth or tinplate, with inner lining of 200-gauge HDPE or in clean and sound bottles, jars, or in pouches of 200-gauge polypropylene or HDPE that are laminated, co- extruded, metallized, or multi-layer plastic

materials. Masala powders are packed in polyolefin pouches that give a shinning appearance to attract consumers.

Spice powder packaged in flexible pouches

Ajwain: The graded product is packed in clean, sound and dry containers such as jute bags, cotton bags, poly woven bags, paper bags, polyethylene laminated pouches, cardboard cartons, tin, grass, plastic container, and wooden cases.

Caraway: The ground form of the spice is packed in dry containers made of tin, glass and notches made of laminated or extrusion metallized multi-layer food grade materials.

Black pepper: It is normally packed in gunny bags. The shelf life of pepper can be extended to one year with no loss in flavour and volatile compounds by using laminates with 40 gsm paper / 0.12mm Al foil / 25µ LDPE, 12µ metallised polyester / 50µ LDPE, 25µ BOPP / 40µ LD – HD, 12µ polyester / 50µ LDPE and 0µ LD – Tie – Nylon – Tie – LD (co-extruded), as suggested by IIP.

Types of packaging material Used

Paper and cardboard cartons: These are least expensive packages which are used to advertise the product and maintain the intact shape when folded. Wax coating on the external surface aids in water resistance while polyethylene coating on the inner surface aids in seal ability. It is not suitable for ground spices as it results in loss of aroma and flavour compounds. As a result, polyethylene pouches packed with spice powders are placed inside cartons to prevent gas migration.

Spices packed in pouch in carton

Aluminium foil: It is widely used for packing ground spices. Due to its opaque nature, it protects the spice from light induced changes and its resistance in gas transmission helps in maintaining

the delicate flavour of spices. It can be laminated with paper on the outside to resist puncture and polyethylene on the inside for heal sealing ability. Aluminium is used in metallized flexible films and collapsible tubes for spice paste products.

Glass: Owing to its rigid and durable nature, glass bottles are used in packing high moisture sensitive spice powders. Glass surface is treated with aluminium, titanium and zirconium to increase its strength. Glass bottles are now available with discharge spouts to pour the required amount of spice paste and in the case of powdered spice, it comes with discharge surface of different pore size.

Glass bottles with spice packaging

Flexible films: Co-extruded flexible films are used in packaging of whole and ground spices due to its durability. The printed flexible pouches are generally laminates of various compositions. Some of the commonly used laminates are:

- Polyester (10 to 12µ thick)/metallised polyester/LDPE
- BOPP/LDPE
- BOPP/metallised polyester/LDPE
- Polyester/Al foil/LDPE

Aluminium Tin and Plastic containers used in spice packaging

A very important aspect to be considered in the selection of flexible laminate, besides the factors mentioned earlier, is the compatibility of the contact layer of the packaging substrate with that of the product packed inside. This needs to be viewed critically for spice powders of turmeric, chilli, ginger, pepper as well as spice mixes containing these spices. The volatile oils present in these spices can react with the contact layer and cause stickiness and can also affect the printing. De-lamination of the substrates may also occur. For these products, it is best to avoid the use of LDPE (low density polyethylene) as the heat sealant or the food contact layer. The better option for sealant or contact layer could be co-extruded film of LD-HDPE (with HDPE in contact with the product) or cast polypropylene. Alternatively, ionomer (surlyn) or EAA (primacor) can also be considered as the sealant layers.

The types of pouches from flexible plastic based materials could be variable:

- Centre seal formation
- Three sides seal formation
- Four sides seal formation
- Strip pack formation

Commonly used packing material for spices:

50 and 85µm LDPE, 50µm HDPE, 50 and 85µm PP, 75µm MXXT cellophane, Double Pouch of glassine gusset inside + 62µm LDPE, Double Pouch 75µm MSAT cellophane inside + 62µm LDPE, glassine/37µm PE laminate, Saran Coated cello/PE laminate, Metallized Polyester 12µm/37µm PE laminate, and Paper/ 0.009mm Al foil/ 37µm PE.

Packaging of dry spice mixes and pastes

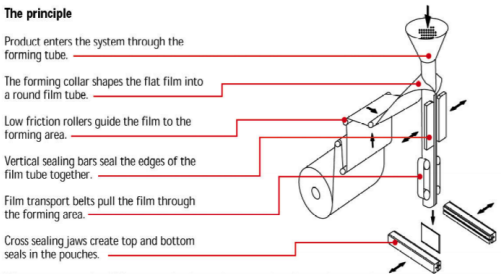
Spice powders and masala mixes are the mixtures of different powdered spices in various combinations. The packaging pattern for dry spice mixes is almost the same as that of powdered spices. Some masala mixes contain ingredients like common salt, black salt, roasted gram powder, etc. other than spice powders. This changes packaging profile to some extent. The addition of salt increases the hygroscopic nature of the product beyond 70% RH. The products that contain black salt give sulphury odour and show tendency to corrode the can or aluminium foil web if the moisture content goes beyond 9%. The critical moisture content for masala mixes ranges between 8-10% which is about 2% less than that of powdered spices. Hence glass jars, tin containers, PET or PET-G jars, AL foil or PET/met PET/PE laminates are the choice materials and can offer 9-12 months shelf life under normal storage conditions. Loss of aromatic flavour due to heat is the limiting factor than light and oxidation leading to flavour deterioration of spices. Hence, cryogenic grinding of spices adds more to their shelf life than any other factor. Nitrogen. Vacuum packaging does not give much beneficial effect for longer shelf life. Micro encapsulation of flavours provides protection for many spice powders and mixes.

Unit packs for dry spice mixes

Packaging machineries for spices

Vertical Form, Fill and Seal (VFFS) machines are automated assembly line packaging systems used in packaging liquids and solids. VFFS machine can be intermittent or continuous motion. Intermittent motion machines operate on the principle that vertical bag seals are made when the film is moving and horizontal seals occur when the film stops. Intermittent motion machines offer a suitable solution for applications where speed is not absolutely paramount. On continuous motion machines the vertical and horizontal bag seals are applied without stopping the film and therefore higher production rates can be achieved. Vertical Form, Fill, and Seal (VFFS) machines

are used in the consumer products industry for a wide variety of packaging applications. Various products like salt, tea, sugar, spices, snack foods, wafers, detergent and candies are placed into formed pouches and then sealed. The pouch material is flexible and typically heat-sealable plastic. Paper is also used and sealed by glue Fully automatic VFFS machines require limited operator intervention. The operator need only replenish product by loading supply hoppers or changing packaging film drums. For machines that are semiautomatic, operators are required to perform part of the packaging operation. VFFS machines can be intermittent or continuous motion. Intermittent motion machines operate on the principle that vertical bag seals are made when the film is moving and horizontal seals occur when the film stops. Intermittent motion machines offer a suitable solution for applications where speed is not absolutely paramount. Continuous motion machines operate on the principle that both vertical and horizontal bag seals are made when the film is in motion. These machines operate at the highest attainable speeds and require a reciprocating sealing jaw motion format.



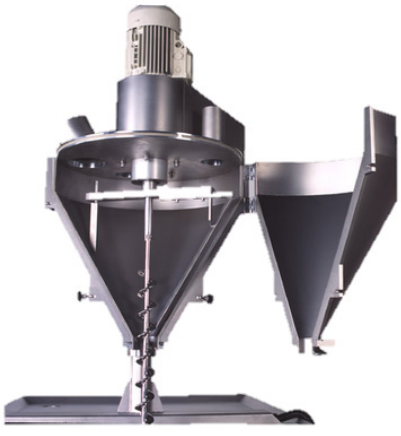

Auger Weigher

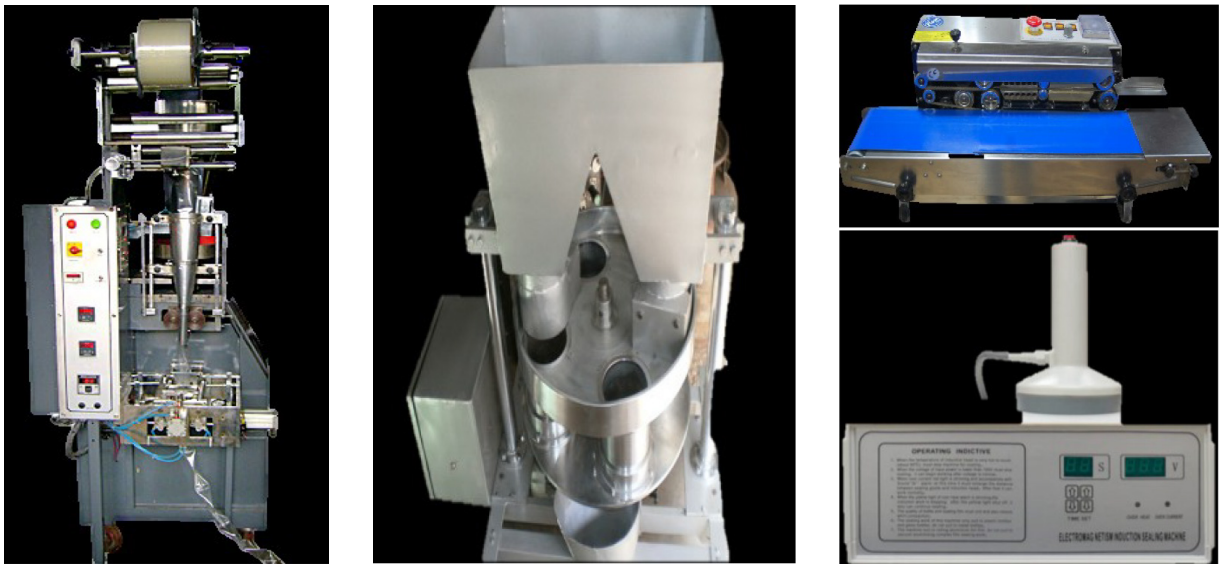

Multi-head Weigher


Volumetric Cup Filler

Filling method machines

Other packaging and sealing Equipments





1 Auger type FFS, 2 Cup type FFS, 3 Impulse leg sealer, 4 Band Sealer, 5 Induction sealing equipment

Spices are distributed in whole, ground and paste form in consumer as well as in bulk packs. Most traditional materials used earlier like paper, tinplate containers and jute bags are being replaced by plastics materials for packaging of these products. Plastics are preferred due to their properties such as light weight, easy availability, compatibility, hygienic nature machineability, printability, heat sealability and selective barrier properties.

CHAPTER 4

PLANT LAYOUT AND MAINTENANCE FOR SPICES AND PLANTATION CROPS PROCESSING

Location of an industry is an important management decision. It is a two-step decision i.e first, choice of general area or region and second, the choice of site within the area selected. Location decision is based on the organization's long-term strategies such as tech¬nological, marketing, resource availability and financial strategies. The objective of plant location decision-making is to minimize the sum of all costs affected by location.

Plant location is important because of the following

(i) Location influences plant layout facilities needed.

(ii) Location influences capital investment and operating costs.

Location decisions are strategic, long-term and non-repetitive in nature. Without sound and careful location planning in the beginning itself, the new facility may create continuous operating problems in future. Location decision also affects the efficiency, effectiveness, productivity and profitability.

Need for location decision arises in following circumstances

(i) When a new facility to be established.

(ii) Expansion of existing facility.

(iii) To establish additional facilities in new territories due to growing volume of business.

(iv) When original advantages of the plant have been out¬ weighed due to new development.

(v) When new economic, social, legal or political factors sug¬gest a change of location of the existing facility.

4.1 Site Selection

The problem of the selection of a factory or a plant can be solved in the following two stages:

(a) The general location of the plant.

(b) The selection of a particular site.

(a) The General Location of the Plant

Following factors must be considered for selecting a region where the factory is to be located:

(i) Availability of Raw Materials.

(ii) Proximity to Markets.

(iii) Transport Facilities.

(iv) Availability of Efficient and Cheap Labour. ¬

(v) Availability of Power and Fuel.

(vi) Climatic and Atmospheric Conditions

(vii) Availability of Water.

(viii) Availability of Capital.

(ix) Social and Recreational Facilities.

(x) Business and Commercial Facilities.

(xi) Existence of Related Industries.

(xii) Other Factors.

(b) Selection of a Particular Site.

After selecting a general area for the plant, next step is to select a suitable site in that area. This is most important decision. If the selection of site is not proper all the money spent will go waste and the owner has to suffer great loss. Therefore, while selecting a site, the owner must consider technical, commercial and financial aspects so as to take maximum advantages. Sometimes, all the requirements and features of suitable site may not be available at one particular location, in such cases it will be advantageous to find out a suitable site with a combination of maximum essential requirements of the particular industry from maximum overall economy point of view.

Important points which should be considered while selecting a site are

(i) Community Attitude.

(ii) Community Facilities.

(iii) Topography.

(iv) Transportation facilities.

(v) Waste Disposal.

(vi) Ecology and Pollution.

(vii) Size of Land.

(viii) Supporting Industries.

4.2. Objectives of Plant Layout and Material Handling

Objectives of plant layout and corresponding objectives of material handling are indicated in the following table

Objectives of plant layout	Objectives of material handling
1. Minimum material handling	(a) Automatic handling. (b) Better control over handling. (c) Larger unit loads. (d) Lesser damage of the materials.
2. Facilitate manufacturing process.	(a) Efficient and orderly flow of material. (b) Minimum of production bottlenecks.
3. Flexibility of arrangement	(a) Flexibility of handling methods and equipment. (b) Material handling planned for ex-pansion.
4. Maximum utilisation of equipment	(a) Reduced handling between opera¬tion. (b) Orderly flow of material. (c) Minimum bottlenecks in handling.
5. Maximum utilisation of floor area	(a) Better space utilisation (b) Use of handling equipment requiring minimum of floor area.
6. Efficient utilisation of manpower	(a) Minimise manual handling. (b) Maximise unit load. (c) Use containers effectively.
7. Care for employee safety and con-venience.	(a) Safer working conditions. (b) Lesser fatigue. (c) Comfortable working conditions.

4.3. Principles of Material Handling Applied to Layout

Following are the main principles which a material handling during the plant layout for least cost and better output These principles are:

1. Continuous Flow: Processing time and costs are minimum when the product progresses through various processes in a continuous flow with a minimum of back-tracking, or cross hauling. For this purpose, the following need to be kept in mind

(i) Slowest process will become the bottleneck.
(ii) Material handling is an integral part of processing and should be examined closely.
(iii) To obtain a direct line of materials flow, wherever possible, and make the routing of materials as automatic as possible.

2. Economy of Operations: Materials handling economy is achieved in a plant when materials are

(i) Moved in a direct line.

(ii) Moved through a minimum distance.

(iii) Moved by mechanical or automatic means.

3. Balancing Operations: Processing costs are minimised and processing cycle time is reduced when equipment, labour, and materials are applied in a plant layout in a balanced relationship. For this purpose, the following need to be kept in mind

(i) Moved in a direct line.

(i) Sequential operations are in balance when each required the same or nearly the same amount of time.

(ii) At each operation there should be balance.

(iii) Lack of balance causes bottlenecks.

(iv) Lack of balance results in equipment not fully utilised. Operations have to wait for materials, materials back up at certain operations, andthere are lot of temporary storage locations.

4. Built-In Flexibility: The plant layout should be designed with a degree of flexibility to provide for future growth and change in process and product.

5. Auxiliary Service Requirements: Necessary services and departments should be provided for the process and its personnel in sufficient quantity and quality. These services can be divided into two categories, namely processing services, and personnel services. Processing Services includes receiving, storage, shipping, maintenance area, laboratories and testing area. Personnel Services includes toilets and washrooms, drinking water, locker rooms, dispensary, cafeteria.

6. Safety: Maximum production is obtained when the potential causes of accidents are reduced to an absolute minimum. For this purpose, remember.

(i) Provide sufficient aisle space for pedestrian and equip¬ment.

(ii) Equipment and work stations should not be crowded.

(iii) Adequate storage space at equipment without crowding to be provided

(iv) Sufficient room at each piece of equipment to be provided.

4.4. Storage Space Requirement

In plant layout, while allotting space for work stations, provision must be made for materials storage space essentially required inside the plants. The space requirement depends on various factors, such as

(i) The quantity of raw materials required to be used per hour.

(ii) Volume and weight of partially processed parts awaiting moving from one machine to the next machine.

(iii) Volume and weight of parts on the move from one department to the next department.

(iv) Volume and weight of scrap.

(v) The ceiling height of the plant building.

(vi) The floor load bearing capacity.

(vii) Total production per assembly.

(viii) The raised ground required for storage.

(ix) Methods to be adopted for storage purpose.

4.5. Type of Machines and Equipment

Machines and equipment may be either general purpose or special purpose. Their requirements are also different in terms of space, speed and material handling process and these factors are given proper consideration while choosing a particular type of layout. Layout should be such that the machineries are used to its fullest capacity. Various classes of machinery that are designed to fit the different shop requirements and the technical and economic operating conditions found in industry are

(i) Manually operated Machinery.

(ii) Semi-automatic Machinery.

(iii) Fully automatic Machinery.

(iv) Standard Machinery.

(v) Universal Machinery.

(vi) Multi-operation Machinery.

(vii) Single-purpose Machinery.

4.6. Plant Layout Procedure

A number of procedures have been developed to facilitate the planning (design) of plant layouts. Following steps are generally considered in designing a plant layout

(i) Procure the basic data.

(ii) Analyse the product and production process.

(iii) Make or buy parts decision.

(iv) Plan the material flow pattern.

(v) Consider general material handling plan.

(vi) Calculate equipment requirements.

(vii) Plan individual work stations.

(viii) Select specific material handling equipment

(ix) Coordinate groups of related operations.

(x) Construct flow diagram for production centres.

(xi) Plan service and auxiliary activities.

(xii) Determine space requirements.

(xiii) Allocate activity area and plot plan.

(xiv) Consider building types.

(xv) Construct master layouts.

(xvi) Seek opinions and suggestions.

(xvii) Evaluate, adjust and select the best layout.

(xviii) Check final layout

(xix) Obtain official approval

(xx) Install the layout.

(xxi) Follow up on implementation of the layout.

4.7. Layout of a New Plant

Following factors are considered in their usual procedural order in organising and laying out plant facilities:

(i) Select equipment on the basis of product design and expected volume of production.

(ii) Collect layout data: machine data, machine load charts and temp lets of equipment.

(iii) Develop process charts.

(iv) Develop an overall flow plan of operations for processing and material handling.

(v) Select the best suited type of building.

(vi) Develop a tentative plot plan.

(vii) Layout temp lets or models of individual product machines according to flow-plan of operations.

(viii) Layout templates and space for service activities: materials handling, receiving and shipping, inspection, storage, maintenance, building services, offices and employees facilities.

(ix) Develop building specifications to house the layout, and modify floor plan considering building limitation.

(x) Make a detailed layout drawing, plot plan drawing, and a layout model (if required).

(xi) Make a flow process chart and a flow diagram to verify the attainment of the objectives of an efficient layout.

(xii) Seek opinions and suggestions on these layout drawings and charts from specialists in various fields, and make modifications, if necessary.

(xiii) Seek management approval on final layout drawing.

(xiv) Construct plant and install equipment.

(xv) Make a test run and adjust layout where required.

4.8. Weaknesses in a Poor Plant Layout

(i) Low output from the plant and equipment.

(ii) Because of improper layout, unused or capacity exists in the plant.

(iii) Lack of flexibility.

(iv) No provision for future low-cost expansion of plant.

(v) Too many. delays, temporary storages, bottlenecks, large amount of goods-in-process etc.

(vi) Difficulty in production planning and supervision.

(vii) Improper utilisation of the plant site.

(viii) Improper sequence of operations.

(ix) Obsolete equipment outmoded processing methods.

(x) Over-specialisation of production facilities.

(xi) Poor capacity balance.

(xii) Improper location of subassembly feeder lines with the final assembly lines.

(xiii) Improper allocation of floor space.

(xiv) Uneconomical and improper materials handling, and lack of gravity handling.

(xv) Inefficient work stations and workplaces that are not laid out in conformance with the principles of motion economy.

(xvi) Service activities, like storerooms, tool cribs, maintenance . shops, inspection cribs, that do not cater effectively to the work floor.

(xvii) Inadequate layout storage facilities. receiving:, aisels, production and shipping floor congested with materials.

(xviii) Poor lighting, ventilation, heating, air cleaning and housekeeping etc.

(xix) Inadequate safety provisions for the protection of workers. Hazards at workplace, materials handling, production, storage etc. .

(xx) Skilled worker moves materials.

(xxi) Back tracking and obstacles in material flows.

(xxii) Many men moving material.

(xxiii) Inconveniently located and inadequate storage and service facilities.

Layout Problems

It is not necessary that layout engineer deals with only new layout i.e. layout problems of new facilities. Such problems are faced only once. However, he is mostly involved in problems related to the re-Iayout of an existing process or an alteration in the existing arrangement. Some of the examples of re-Iayout problems are:

(i) Change in design of part or change in method of produc¬tion.

(ii) Expansion or reduction in production capacity.

(iii) Diversification i.e. addition of a new product.

(iv) Planning a new facility or a new department.

(v) Shifting a department.

(vi) Replacing an equipment with advanced technology.

WATER AND POWER REQUIREMENT

Water

Water is one of the essential factors in the activity of the processing centers, according to the final utilization; water can be classified in three categories.

(i) For technological utilization (when it come into direct contact with raw materials and enters in the finished products composition)

(ii) For steam generators and

(iii) For receptacle cooling, washing of equipment and general hygiene.

Water conservation method

(i) The supply of water requires energy for production, transportation, purification, and waste treatment. Consequently, saving water will save energy and cost as well.

(ii) Stop leaks and use automatic- off faucets or sheet off water lies left running for no reason.

(iii) Consider reducing the temperature of hot water for personal use and turning water heating down or off on weekends.

(iv) Make a through study of the use processing water with the objective of accomplished necessary washing and cool without waste and with the maximum resource of water consider the installation or extension of counter flow use of water and the reuse of empty can wash water for washing of filled and sealed cans.

(v) Check the frequency of clean up needed for maximum efficiency and use high pressure-low volume for quick cycle clean-ups.

(vi) Consider clean-in-place systems for specific applications.

Electric Power Conservation Method

(i) A systematic review of the entire electric power system should be used.

(ii) Loose drive belts waste power.

(iii) Over loaded motors waste power in the form of heat and are obviously undesirable because the unnecessary stress will shorten the service life of the motor. All driven equipment should be well lubricated and checked for free operation to minimize frictional loading and reduce risk of overheating.

(iv) Under loaded motors waste power. They also lower the power factor, which can increase hilling charges. Improving the power factor will definitely save energy.

(v) In most areas, improvement of the power factor by installation of capacitors cannot be justified on a saving basis. The possibility should not, however, be summarily written off.

(vi) Reducing the maximum demand load by possible shifting of heavy load to off- load hours will be reflected in lower power hills will not in itself save energy except in the unlikely instance where the facility is a major customer of a small utility. It may be of value in an overall area electrical shortage.

(vii) Do not operate stand by equipment when the primary equipment can carry the load and turn off electric motors during non- production periods.

4.9. General Sanitary Standards

General maintenance

The plant and all texture must be kept in good repair and be maintained in a sanitary condition cleaning operation must be conducted in a manner that will minimize the possibility of contaminating foods or equipment surface that contact food.

Pest control

(i) No animals or birds to be allowed anywhere in the plant.

(ii) Programs must be in effect top prevent contamination by animals, birds and pests, such as rodents and insects, by animals, birds and pests, such as rodents and insects.

(iii) Insecticides and rodenticides may be used as long as they one used properly (according to label instructions)

(iv) These pesticides must not contaminate food or packing materials with illegal residues.

Sanitation of equipment and utensils

Utensils and equipment surface that are in contact with food must be cleaned as often as necessary to prevent food contamination. Equipment surfaces that are not in contact with food should be cleaned as frequently as necessary to minimize accumulation of dust, dirt, food particles, etc.

Storage and handling clean portable equipment and utensils

(i) This refers to portable equipment or utensils, which have surfaces that will contact food.

(ii) When such equipment or utensils have been cleaned and sanitized, they should be stored in a manner that will protect the food contact surfaces from splash, dust and other contamination.

Sanitary Facilities and Controls

Water supply

Any water that comes into contact food or processing equipment must be safe and of adequate sanitary quality.

Sewage disposal

Must flow into an adequate sewage system or disposal through other adequate means.

Plumbing

(i) Supply enough water to areas in the plant where it is needed.

(ii) Properly convey sewage or disposable liquid waste from the plant.

(iii) Not create a source of contamination or unsanitary condition.

(iv) Provide adequate floor drainage where housing- type cleaning is done or where operations discharge water or liquid waste on to the floor.

(v) Insure that there is no backflow from cross- connection between piping systems that discharge wastewater or sea wage and those that carry water for food or food manufacturing.

Toilet facilities

(i) Toilets and hand washing facilities must be provided inside the main processing centre.

(ii) Toilet tissue must be provided.

(iii) Toilets must be kept sanitary and in good repair.

(iv) Toilets rooms must have self- closing doors.

(v) Toilets rooms must not open directly into areas where food is exposed unless steps have been taken to prevent air borne contamination (example: double doors, positive air flow, etc).

(vi) Signs must be posted that direct employees to wash their hands with soap or detergent after using to toilet.

Hand washing facilities

a) Adequate and convenient hand washing and, it necessary, hand sanitizing facilities must be provided anywhere in the plant where the nature of employees jobs requires that they wash, sanitizer and dry their hands.

b) These hand-washing facilities must provide.

- Running water at a suitable temperature.
- Effective hand cleaning and hand sanitizing preparations.
- Clean towel service or suitable drying devices.
- Easily cleanable waste receptacle.
- Water control valves designed recontamination of clean, sanitized hands.
- Signs directing employees handling on
- Protected food to wash and, if appropriate, sanitizer theirs hands before starting work, after each absence from the workstation, and any other time, when the hands have become soiled or contaminated.
- Rubbish and offal disposal must be handled in such a manner that they do no

serve to attract or harbor pests or create contaminating conditions.

4.10. Maintenance of Food Industry

In food manufacturing, maintenance supports various key objectives, a number of which are unique to food production. Among the roles that maintenance plays in food manufacturing are the following.

a) Keep production going

Like any other industry, one of the key roles of maintenance in food production is to keep processes going without unplanned downtime. The better that food and beverage manufacturers keep up on their equipment upkeep, the lower the chances will be that their processes are interrupted by a breakdown.

b) Food safety

Most industries need to make sure their products are safe to use, but for the food industry, product safety is an even higher priority. Given that people eat and drink the items that leave their facilities, food manufacturers need to be absolutely certain that everything they produce is completely unspoiled and free of harmful contaminants.

Keeping production line equipment in good condition helps prevent contamination while making sure foodstuffs come off their line properly prepared for consumption.

c) Reduce lost products

Whenever equipment breaks down in a food manufacturing facility, it puts the product itself at risk. The longer food is left to sit out, the higher the chances they will have to be discarded, due to spoils. For products that have strict temperature control requirements, the likelihood of food going bad increases. In a facility that produces thousands of pounds of product every day, that can result in massive losses in addition to the reduced production time.

Naturally, preventing breakdowns with preventive maintenance can all but eliminate these losses.

d) Maintain regulatory compliance

Given the fact that people ingest the products that come out of food factories, there are many strict regulations that manufacturers in this industry must comply with. Failing to comply with those standards results in hefty fines, as well as a lost reputation as a manufacturer.

Maintenance work helps keep machines in a state that complies with federal standards, such as the Current Good Manufacturing Practices (CGMPs).

4.11. Common Maintenance Challenges in Food Manufacturing

Food manufacturing faces a number of challenges that most other industries don't have to deal with, at least to the same extent. These challenges include the following.

a) Strict regulations to follow

Like other industries, food manufacturers have to comply with standards, Inspections can happen at any time, so the facility needs to always be kept in strict compliance. In addition, these standards can change from time to time, with the level of scrutiny and strictness generally increasing as time progresses.

b) Cleanliness standards and wet environments

To keep up withregulations and prevent contamination, food factories need to be kept spotlessly clean. Everything from random debris to flakes of rust and paint need to be kept clear from foodstuffs, in order to make sure the product is completely safe for consumption, so frequent cleaning is vital to a food manufacturer's operations.

c) Complex equipment

Aside from the challenges of keeping equipment clean, they also need to be working at all times. The machines used in continuous food manufacturing processes are often highly complex, and there's very often a need for specialized training to diagnose problems with each individual piece of equipment.

d) Continuous processes

The difficulty of maintaining food production equipment is only compounded by the fact that it is often used as part of a continuous process. Finding the right time to perform inspections or routine maintenance might be difficult when different tasks have their own schedules.

e) Perishable products

Along with the downtime caused by breakdowns, the product itself is at risk if the equipment goes offline. Some machines need to be serviced quickly, in order to prevent as much losses as possible, but at times, that may not be possible.

f) Stringent quality control

Quality control is key when it comes to food production. In addition to making sure food products are safe for consumption, QC issues such as making sure it has the right flavor, avoiding damage to the packaging, and so forth are all vital.

4.12. Importance of Equipment Maintenance

An effective maintenance routine makes sure that operations continue, repair costs are minimised, and downtime is reduced.

Preventative maintenance: is the checking of machines and equipment on a planned, regular basis. The aim is to prevent costly downtime and lessen the likelihood of faults. It requires more planning and effort than other methods – but has long and short-term benefits in cost-reduction and efficiency of machine performance.Preventative checks are made before a machine breaks and while it is still running. Generally, the strategy leads to good food hygiene and prevents foreign

materials entering food produce. Plants that use the preventative method have a far greater chance of catching and correcting issues before they become problems. The method uses a fair amount of labour time to perform the checks – but it pays off.

Preventative Maintenance Procedures

A preventive method is more complex than a run-to-failure (or reactive) method. But it's less complex than a predictive method.

A preventative method will involve things like conducting safety checks, cleaning parts, and replacing parts. The following Checklist for Planning Preventive Maintenance

(i) Identify the assets that require preventative maintenance.

(ii) Distinguish what kind of safety checks the machine will need.

(iii) Assess whether parts need replacing or cleaning.

(iv) Decide how regularly assets need checking.

(v) Create a formal risk assessment process to help the person responsible for checks.

(vi) Talk to employees who work closely with equipment to discover more about how the machines are operating at the time of the check.

(vii) Find out if parts need cleaning, lubricating or changing.

This checklist isn't exhaustive. Instead, it gives you an idea of what you might need to do to plan your preventive maintenance procedures.

Preventive maintenance is important for the following areas

(i) Operational efficiency: A well-maintained machine is a top-performing machine. With fresh lubricant, better calibration, and cleaner systems, your equipment will be able to keep your plant running smoothly.

(ii) Functional performance: In addition to operating faster and with fewer interruptions, the quality and consistency of the food you produce will also improve, such as more consistent cooking times and temperatures.

(iii) Food safety: Better-maintained equipment also means higher safety standards for the food it processes. Poorly maintained equipment is more likely to break down during manufacturing, compromising the integrity of the food or leading to false readings of temperature or other important factors.

(iv) Documentation and tractability: Adhering to a maintenance schedule helps you keep better tabs on the performance of your facility, aiding in root cause analysis should something go wrong, and giving you proof of maintenance in the event of a third-party audit.

(v) Repair costs.: Just as changing the oil in your car regularly can save you money on more costly repairs down the line, maintaining your equipment on a fixed schedule can help you make the most of your equipment investments.

Steps to be taken for consistent preventive maintenance

(i) Take inventory and assess risk.

(ii) Set a schedule and optimize timing.

(iii) Document proper procedures. .

(iv) Designate authority.

(v) Keep necessary items and equipment on-hand.

(vi) Be prepared for temporary fixes.

(vii) Keep detailed maintenance records.

Other Maintenance Approaches

a) Reactive Maintenance: Itis a method where machines run until they fail. It's a hands-off approach (which can't really be called a strategy), and the big benefit is that it keeps routine maintenance costs low. But, and here's the big but, it tends to be costly in the long run.Organisations who use this method find that costs arise in other areas. So when a machine fails without warning, the plant has a lot of expensive downtime. Also, it's likely that the downtime will increase labour costs to get the machine operational again. Making it, all in all, an inefficient method.

b) Predictive Maintenance: It uses advanced technology during the routine inspection of machines. This method can stop unexpected breakdowns and by using advanced tech, factories can minimise the amount of time needed to inspect equipment piece by piece. This method checks machine health and the data provided allows the person accessing the machine to estimate when repairs are going to be needed and to predict when a failure might happen.

c) Proactive Maintenance:It is a systemic issue-focused maintenance program. Rather than examining equipment, this approach considers how to control the problems that lead to machine wear and tear as opposed to the deterioration itself.

Machine Maintenance Logs

After completing any preventative maintenance, you should complete a log.This log entry should include a description of the work carried out, who carried it out and the date and time that it happened.

Logs are also a good source of data which you can use when you want to know whether or not to fix or replace a machine. logs also provide you with a record of due diligence evidence in case a machine fault happens.

4.13 Food Plant Design Process – An Insight

Plant design process generally starts with conceiving of project idea. Once the idea for a particular project is ready then the next step is feasibility study. Technical, commercial, social, economic

and financial viability need to be analyzed. If the results of these studies are found to be favorable then the next step is engineering design of plant. Food process plant design on all projects follow the same stages of development. However, the extent and detail of the activities behind each stage varies with each project. Out line of food processing plant design is given as Fig. 1

Project idea

It is conceiving of idea for possible plant design situations like introduction of new products, addition of new equipment to the existing plant etc. The idea may come from customers, distributors, competitors, sales people or the entrepreneur/owner. A new product selection may be to satisfy the need of a customer or to explore newness in the market. Screening of various ideas based on capital requirement, government policies and regulations are done, to select the best one.

Feasibility analysis

The feasibility analysis is a detailed study of technical, commercial, economical, financial and social aspects of the proposed project idea. Accordingly, feasibility report is prepared and thoroughly examined to make an informed decision. It consists of two stages.

1. Pre-selection/pre-feasibility stage
2. Analysis stage

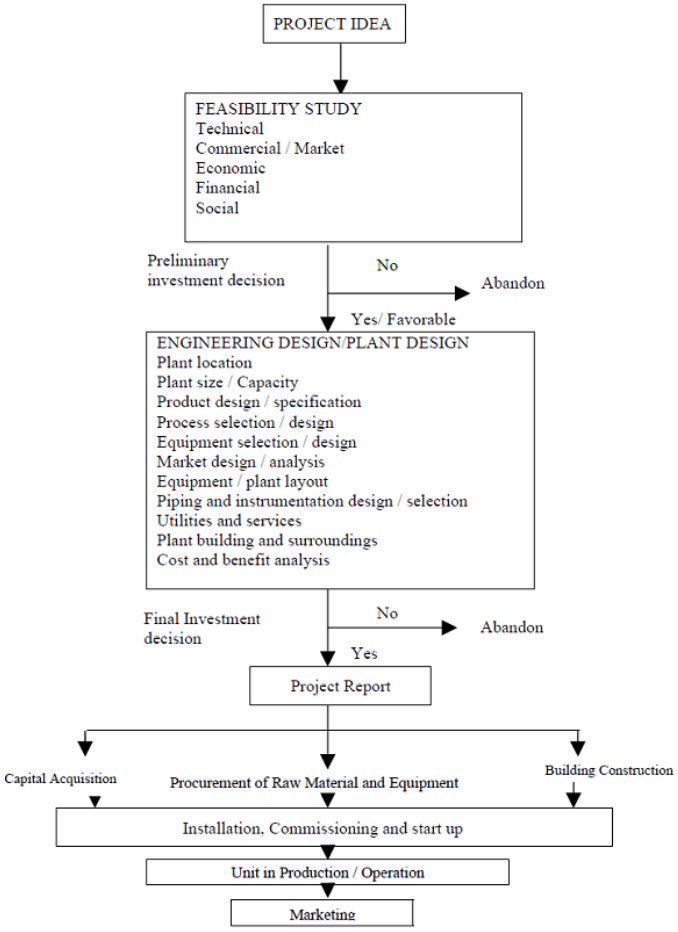


Fig 4.1: Outline of food processing plant design

Pre-feasibility stage

In this stage, preliminary screening is conducted to select only those ideas which appear to be worthy of further study so as to avoid loss of time and money. Mostly, raw material availability and market potential of the product receive greater emphasis in this stage.

Generally, pre-feasibility report has the following details,

(i) Description of product and market

(ii) Availability of raw materials and utilities

(iii) Statement of anticipated major problems and risks

(iv) Cost and profit estimates

Analysis stage

At analysis stage, various alternatives in marketing, technology and capital availability is thoroughly studied. It is also referred to as techno-economic feasibility study. The report of the study includes the following.

a) Market/commercial analysis

It involves systematic collection of information, to study and evaluate the idea with respect to market. It provides,

(i) Understanding of the market (size, demand, buying habit, market trend, marketing and distribution channel, our strength in the market)

(ii) Information on feasibility of marketing the product

(iii) Estimated market share of the project

b) Technical analysis

It is the study of project idea in terms of technical details so as to arrive at a conclusion whether the conceived idea is technically feasible or not. Technical details of the following are considered for analysis,

(i) Raw material and product – specifications/composition

(ii) Equipment – design and selection details

(iii) Technology and methods – manufacturing process, flow charts, production schedule

(iv) Organization – plant lay out and size,

(v) Location and design – raw material availability and market for the product

(vi) Cost estimation – fixed and variable cost, Startup expenses

(vii) Type and quantity of waste to be disposed

c) Financial analysis

It includes preparation of financial statement for the project which can be evaluated for profitability and financing requirements. The overall objectives of the financial analysis should include,

(i) Audited financial statements of existing companies – balance sheets, income and cash flow statements

(ii) Financial statements of new companies and future financial projections with supporting documents

(iii) Financial analysis – return on investment, return on equity, break-even point analysis

(iv) Sensitivity analysis – Profitability and risk analysis

d) Economic and social analysis

Economic analysis is concerned with the outcome of a particular project idea on the society as a whole. It measures the positive and negative effects of projects on the society. In addition, economic analysis covers costs and benefits of goods and services producedwhich has no market value.

Social analysis is the evaluation of project idea on social characteristics of the society such as quality of life, social service and justice. It evaluates the project impact on individuals, governments, economies, groups and environments.

4.14. Process Flow Chart/Process Flow Diagram

In food process design, flow charts similar to those of chemical process design are used, i.e. process block diagram (PBD), process flow diagram (PFD), process control diagram (PCD), and piping and instrumentation drawings (PID). A process flow chart is a general description of a production process, depicting sequence of different unit operations in production line (A sample given as Fig. 2). On the other hand, process flow diagram shows more details of the process, using specific symbols for equipment, piping and utilities (ew samples given as Fig.3). Few Symbols used in material handling equipment is given as Fig. 4. Sample general layout for spice and cashew processing is given as Fig 5 and Fig. 6. respectively. In addition, PFD shows additional process details like material flow rates (kg/h), energy flows (kW), temperature (°C), and pressures (bar). PCD shows the position of the control units whereas PID shows the type and location of instrumentation. The following details has to considered for drawing process flow diagram (PFD),

(i) Annual output/production

(ii) Plant operation (Number of days per annum)

(iii) Number of shifts per day

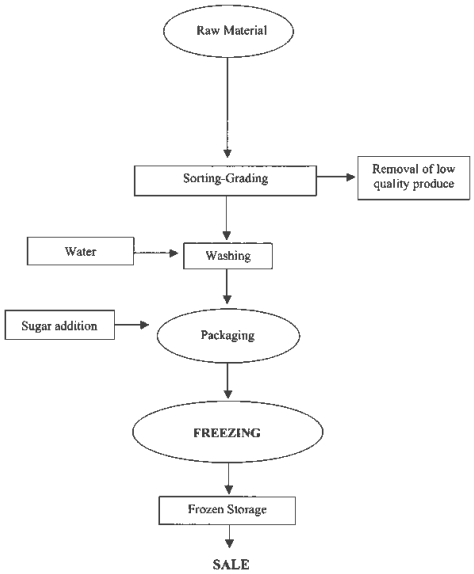


Fig.4.2: Process flow chart for freezing treatment

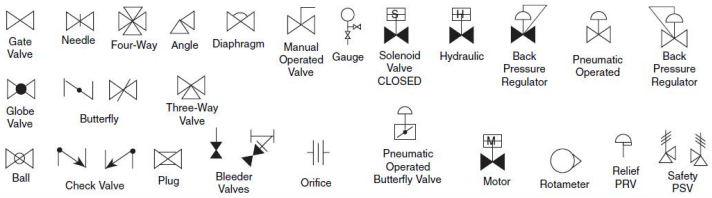


Fig. 4.3: Symbols used to represent different valves

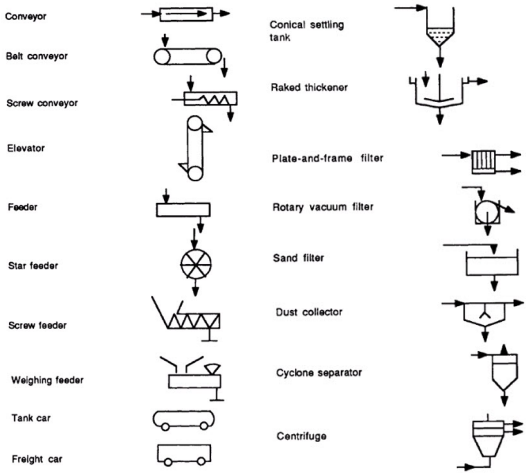


Fig. 4.4: Symbols for material handling equipment

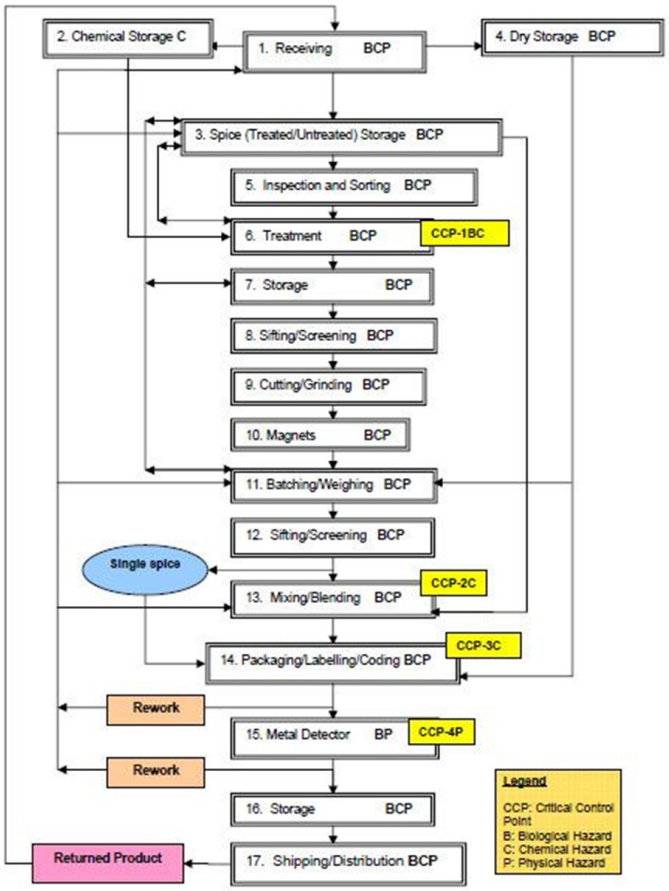


Fig.4.5: Sample layout for spice processing

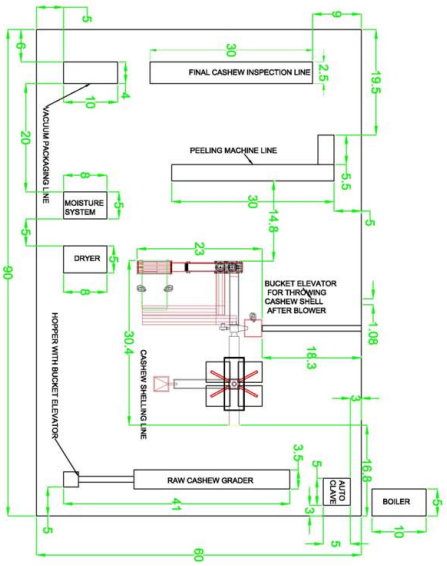


Fig. 4.6: Sample lay out for cashew processing

Technical and managerial decisions are also important in making feasibility analysis, besides economic feasibility for any agro based industries. The important areas where technical factors are involved and require considerations, are, plant location analysis, plant layout and design, machinery - maintenance and replacement and sanitation. Consideration of these factors help in achieving the production level, product quality, higher profit, etc.

CHAPTER 5

FOOD SAFETY REGULATIONS & CERTIFICATION

As the world population continues to grow, the global market for food products is expanding, together with an increased emphasis on food safety. Consumers have become more discerning in the type of foods they buy and how these foods affect their health and well-being. Food safety is generally defined as the assurance that the food will not cause any harm to the consumer when it is prepared and/or eaten according to its intended use. To achieve food safety, a management system has been developed which focuses on preventing problems before they occur, rather than trying to detect failures through end product testing. It also places more responsibility for ensuring food safety on food manufacturers, who have to develop control and traceability of their products from 'farm to plate'. The system requires the identification of specific hazards throughout the entire process of food production, concentrates on the points in the process that are critical to the safety of the product, and highlights measures for their control.

In quality management, there are different kinds of systems viz;, Good Agricultural Practices (GAP), Good manufacturing Practices (GMP), Good Hygienic Practices (GHP) and Hazard Analysis and Critical Control Points (HACCP) – the system which includes the area of food health and quality assurance. HACCP should be regarded as a problem-solving tool which can be used to identify hazards and risks throughout a food processing unit. This includes analysis of raw material sources and usage, processing equipment, operating practices, packaging and storage, together with marketing and conditions for intended use. There is less reliance on the traditional system of end product testing and food safety is built into the product from conception through design and distribution. Implementation of HACCP systems in production plants for processing food should be preceded by implementing principles of Good Production Practice (GPP) and GHP. GMP is a description of all the steps in a processing facility, while HACCP is a documentation that the steps important to consumer health are under control. Sanitation standard operating procedures (SSOPs) are also a needed pre-requisite to HACCP.

5.1. Food Safety Management System (ISO 22000 and FSSAI)

ISO 22000 is a standard developed by the International Organization for Standardization (ISO) as a requirement for the food chain organization to enhance food safety. It was developed as an improvement to ISO 9000. In comparison with ISO 9000, the standard is more procedure-oriented than principle-based. The ISO 22000 international standard specifies the requirements for a food safety management system and the elements of interactive communication, system management, pre-requisite programmes and HACCP principles.

The problems posed during transport of raw material, handling, processing, packaging, and waste disposal are considerable. There have been considerable efforts in improving food safety/quality scenario in the country by many governmental agencies. These include grading, certification and inspection measures such as those under Agmark, BIS, FPO, MMPO, EIC, as well as the developmental activities of agencies like APEDA, MPEDA, Ministry of food processing industries, and commodity boards. While each one of these operates under its own legislative provisions with a clear objective, they do have a positive impact on food safety and quality, which could be further enhanced through better coordination within an integrated system.

The Food Safety and Standards Authority of India (FSSAI) has been established under the Food Safety and Standards Act, 2006 as a statutory body for laying down science based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food so as to ensure safe and wholesome food for human consumption.

5.2. Need for Testing of Food

Food Testing is a scientific analysis of food and its content. It is done to provide information about various characteristics of food, including the structure, composition and physicochemical properties. Food testing laboratories plays an important role in safeguarding food supply and maintaining public health.

Food testing labs are also critical for investigating and identifying sources of food borne illness outbreaks, as well as conducting food safety tests during recall campaigns to ensure, for example, that all affected products are removed from store shelves and restaurants.

It is also conducted to analyze:

1) The quality of food products- this is done to verify the claim made by the manufacturer of the product on certain issues e.g. ingredients used

2) For quality control- this is done before, during and after the manufacturing process to analyse the quality of the food ingredients and the finished products.

3) Food inspection and grading- is performed regularly to ensure food manufacturer meet the set regulations and standards.

4) Food must have a standardized nutritional label therefore food needs to be analyzed to verify the claims made

5) Research and development is necessary for manufactures to improve and provide food high quality, healthy and affordable food, this requires studying and analyzing the products already in the market.

6) To protect a manufacturer from rumours and smears. Many products in the market is being labelled by competitors or other rumour, such rumours can be sorted out.

Over time, the mandate for food testing labs has been expanding far beyond what was originally envisioned within the Food Code. For example, large chain restaurants are now required to post the caloric content of their menu items so consumers can make more informed dietary choices.

Testing for the presence of food allergens is another example. An increasing number of people are at risk for an anaphylactic shock when exposed to certain kinds of foods, from peanuts red meat to certain kinds of seafood. As a result, food testing laboratories have been called on to certify food products as being nut-free or to identify the exact species of fish served at restaurants.

5.3. List of Notified Reference Laboratories in India

S.No.	Name of the laboratory/ Institution/Organization	Address	Specific area
1.	Central Food Technological Research Institute	FS & AQCL Department, CFTRI, Mysore-570020	Nutritional Information and labelling
2.	Export Inspection Agency	27/1767A, Shipyard Quarters Road Panampilly Nagar, Kochi, Kerala 682036	GMO testing
3.	Punjab Biotechnology Incubator	SCO 7-8 Phase-V, SAS Nagar, Mohali-160059, Punjab	Sweets and confectionary including honey
4.	ICAR-National Research Centre for Grapes	P.O. Manjiri Farm, Solapur Road, Pune -412307	Pesticide Residues and Mycotoxins
5.	Central Institute of Fisheries Technology	CIFT Junction, Wellingdon Island, Matsyapuri, PO -Kochi	Fish and Fish Products
6.	Centre for Analysis and Learning in Livestock and Food-National Dairy Development Board	Opposite IRMA main gate, Near Anadalaya Nagar, Anand 388001.	Dairy and Dairy products
7.	CSIR-Indian Institute of Toxicological Research	Vishvigyan Bhawan, 31 Mahatma Gandhi Marg Lucknow-226001	Toxicological Evaluation/Risk Assessment for Nutraceuticals, functional foods and novel/ emerging food/food ingredients

8.	Trilogy Analytical Laboratory, Pvt. Ltd.	Plot No.7, C.F. Area, Phase II, IDA, Cherlapally, Hyderabad	Mycotoxins and PT services
9.	Edward Food Research and Analysis Centre Limited	Subhash Nagar, Nilgunj Bazar, Kolkata	Veterinary Drugs, Antibiotics and Hormones
10.	Vimta Labs Limited	Life Sciences Campus, 5, MN Park, Genome Valley, Hyderabad-500101	Water, Alcoholic and Non Alcoholic Beverages
11.	Fare labs Pvt Ltd	L-17/3, DLF, Ph-II, IFFCO Chowk, Gurugram-122002	Oils and Fats
Ancillary National Reference Laboratory			
13.	EIA Chennai	Chennai	Support Facility in microbiological testing
14.	EIA Kolkata	Kolkata	Support Facility heavy metals in food testing

List of Notified Referral Laboratories in India

S. No.	Name of the Referral Food Laboratory	Local Areas or States or Union Territories
(1)	(2)	(3)
1.	(i) Director, Central Food Laboratory, 3 Kyd Street, Kolkata -700016.	West Bengal, Orissa, Bihar, Jharkhand, Assam, Arunachal Pradesh, Chhattisgarh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Union Territories of Andaman and NicobarIsland
	(ii) Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	
2.	(i)Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore –570013.	Andhra Pradesh, Karnataka, Kerala Tamil Nadu, Telangana, Puducherry and Lakshadweep
	(ii) Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	
3.	(i) Director, State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pune-411 001.	Gujarat, Maharashtra, Madhya Pradesh, Rajasthan, Dadar and Nagar Haveli, , Goa and Daman and Diu
	(ii) Director, Food Safety and Analytical Quality Control Laboratory, C/o. Central Food Technological Research Institute, Mysore –570013	

4.	(i) Director, Food Research and Standardization Laboratory, Ahinsa Khand-II, Indirapuram, Ghaziabad-201014.	Delhi, Haryana, Himachal Pradesh, Punjab, Union Territory of Chandigarh, Uttar Pradesh, Uttarakhand and Jammu & Kashmir
	(ii) Director, Central Food Laboratory, 3 Kyd Street, Kolkata 700016.	

List of Notified Referral Laboratories and their scope

S. No.	Name of the Referral Food Laboratory	All over India -as per Scope of Testing defined here under
(1)	(2)	(3)
5.	Director, Indian Institute of Horticultural Research, Hessaraghatta lake post, Bangalore -560 089.	Pesticide residue analysis of fruits and vegetables, cereals and pulses, water, spices (curry leaves), Nutritional, Proximate and microbiological analysis of fresh and processed food products.
6.	Director, Indian Institute of Vegetable Research, Post Bag No. 01; P.O. Jakhini, (Shahanshapur), Varanasi -221 305.	Analysis of pesticide residue, heavy metals, microbial contaminations, mycotoxins, antibiotics, disinfectants, colouring agents, adulterants, food additives, phytohaemagglutinin, allergens etc. in Vegetables.
7.	Director, Quality Evaluation Laboratory, Spices Board, Palarivattom P.O., Kochi – 682025.	Analysis of chemical contaminants (pesticide residues, heavy metals, illegal dyes and any other chemical contaminant), mycotoxins (aflatoxins, ochratoxin etc.), microbial contaminants, physical contaminants and adulterants in Spices.
8.	Director, Quality Evaluation Laboratory, Spices Board, Chuttugunta Center, GT Road, Guntur – 522004.	-Do-
9.	Director, Quality Evaluation Laboratory, Spices Board, Plot No. R-11, Sipcot Industrial Complex, Gummidipoondi, Thiruvallur District, Chennai – 601201.	-Do-

10.	Director, Quality Evaluation Laboratory, Spices Board, First Floor, Banking Complex II, Sector 19A, Vashi, Navi Mumbai – 400703	-Do-
11.	Acting Director, Centre for Analysis and Learning in Livestock in Food (CALF), National Dairy Development Board (NDDB), Anand – 388001, Gujarat	Milk and Milk Products, Analysis of pesticides, antibiotics and veterinary drugs, microbial contaminants and mycotoxins, heavy metals, Polycyclic Aromatic Hydrocarbons, dioxin, other emerging contaminants and Microbial parameters in milk and milk products.
12.	Director, Council of Scientific and Industrial Research -Indian Institute of Chemical Technology, Uppal Road, Tarnaka, Hyderabad – 500007	Analysis of moisture, hexane insoluble matter, acid value, unsaponifiable matter, iodine value, saponification value, allyl isothiocyanate, Reichert Meissl value, peroxide value, fatty acid composition, presence of animal body fat in the vegetable fat, cold test, test for physical properties, nickel in vanaspati, phosphorous in soyabean oil, presence rancidity,
13.	Director, National Research Centre on Meat, Chengicherla, Buduppal, Hyderabad – 500092	Physico-chemical analysis (meat species identification, proximate composition, pH value, water holding capacity, meat pigments, emulsifying capacity, free fatty acid, peroxide value, TBA value, cholesterol content, nitrite content, sensory evaluation, texture & tenderness of meat & meat products, instrumental colour value, COD level of slaughter house effluent), Microbiological analysis, Pesticide Residues and Fatty acid profiles of meat and meat products".
14.	Director, Indian Institute of Crop Processing Technology, Food Safety and Quality Testing Laboratory, Pudukkottai Road, Thanjavur – 613005, Tamil Nadu	Nutritional, Proximate and Microbiological analysis of fresh and processed food products; Packaged Drinking Water analysis; Analysis of pesticide residues, heavy metals and microbiological analysis of Cereals and Cereal Products and Spices."
15.	Director, Central Institute of Fisheries Technology, Indian Council of Agricultural Research, Willingdon Island, CIFT Junction, Matsyapuri P.O., Cochin – 682029, Kerala	Physio-chemical analysis, Bacteriological Tests, detection of Viruses, Bacterial toxins, Antibacterial substances, other microbiologicaltests, analysis of pesticide residues & heavy metals in Fish & Fishery Products.

16.	Director, Indian Institute of Integrative Medicine, Council of Scientific & Industrial Research, Canal Road, Jammu-Tawi-180001	Analysis of Aflatoxins, Free fatty Acids, Peroxide value, Iodine value, Pesticide residues, Metals & Other soluble Residues in Nuts; Presence of Moisture content, Specific gravity, Reducing sugar, Fructose-Glucose Ratio, Acidity, Ash content, Analysis of Heavy Metals, Pesticide residues in Honey; Analysis of Aflatoxins, Energy Organics, Vitamins, Total fatty Acids, Total Saturated Fatty & Unsaturated Fatty acids, pesticide residues & heavy metals in Nutraceuticals.

List of State/ Public Food Laboratories

S.No.	State/UT	Laboratory Address
1.	Andaman & Nicobar Island	State Food Laboratory, G.B. Pant Hospital Campus, Andaman & Nicobar Islands, Port Blair – 744103
2.	Andhra Pradesh	State Food Laboratory, Nacharam Industrial Area, Hyderabad – 501507
3.	Andhra Pradesh	Regional Public Health Laboratory, Govt Hospital Complex, Pedda Waltair, Visakhapatnam - 530017
4.	Assam	State Public Health Laboratory, Bamuni Maidam, Guwahati 21, Assam
5.	Bihar	Combined Food & Drugs Laboratory, Agamkuan, Patna – 800 007
6.	Chhattisgarh	State Food Testing Laboratory, Near Mahila Police Station, Opp. Nagar Nigam Office, K alibari, Raipur
7.	Delhi	Combined Food & Drugs Laboratory, Directorate of PFA, NCT of Delhi, A- 20,
8.	Jharkhand	State Food & Drug Laboratory, Namkum, Ranchi Tata Road, Ranchi – 834010
9.	Goa	Food and Drug Laboratory, Directorate of Food & Drugs Admn. DHANWANTARI, Opp, the Shrine of Holy Cross, Bambolim – Goa – 403202
10.	Gujarat	Public Health Laboratory, Urban Health Centre Bldg, Nr. Lal Bungalow, C.G. Road, Navarangpura, Ahmedabad 380009
11.	Gujarat	Food and Drugs Laboratory, Near Polytechnic College, Nizampura, Vadodara – 390 002
12.	Gujarat	Public Health Laboratory, Municipal Corporation, Laheripura Road, Vadodara - 390 001
13.	Gujarat	Regional Food Laboratory, New Lotus Ring Road, Nr. Mahakali Temple, Opp. District Panchayat Staff Quarters, Bhuj, Kutch - 370001
14.	Gujarat	Regional Food Laboratory, University Road, Nr. Forensic Lab, Opp. Kidney Hospital, Rajkot, Gujarat - 360005

15.	Gujarat	Public Health Laboratory, Surat Municipal Corporation, 304, Ambedkar Shopping Centre, Mann Darwaza, Ring Road, Surat – 395003
16.	Haryana	District Food Laboratory, Civil Hospital, Karnal – 132001
17.	Haryana	State Food, Water and Excise Laboratory, Govt. of Haryana, Ground Floor, Sector – 11 D, Chandigarh
18.	Himachal Pradesh	Composite Testing Laboratory, Kandaghat, Distt. Solan, Himachal Pradesh
19.	Jammu & Kashmir	Public Health Laboratory, PatoliMangotrian, Jammu
20.	Jammu & Kashmir	Public Health Laboratory, Nr. CD Hospital, Dalgate, Srinagar
21.	Karnataka	State Water and Food Laboratory, Public Health Institute, Sheshadri Road, Bangalore- 560 001
22.	Karnataka	Bruhat Bangalore MahanagaraPalike Laboratory, Dasappa Hospital Compound, N R Circle, Silver Jubilee Park Road, Bangalore - 560002
23.	Karnataka	Divisional Food Laboratory, Umar Khayam Road, Tilak Nagar, Mysore- 570001
24.	Karnataka	Corporation Laboratory, Corporation of the city of Mysore, Corporation office Building, Mysore
25.	Kerala	Regional Analytical Laboratory, Kakkanand, P.O. Ernakulam, Kochi
26.	Kerala	Regional Analytical Laboratory, Malaparamba, Kozhikode – 673009
27.	Kerala	Government Analyst Laboratory, Vanchiyoor P.O Red Cross Road, Thiruvananthapuram - 695035
28.	Madhya Pradesh	State Food Laboratory, Controller Food and Drug Administration, Idgah Hills, Bhopal - 462001
29.	Madhya Pradesh	Food Laboratory, Municipal, Corporation, Shivaji Market, Nagar Nigam Road, Indore
30.	Madhya Pradesh	State Food Testing Laboratory, Municipal Corporation, Chhatrapati Shivaji Bhavan, Agar Road, Ujjain
31.	Maharashtra	Regional Public Health Laboratory, Nizam Bunglow, Cantonment Area, Aurangabad - 431002
32.	Maharashtra	District Public Health Laboratory, Dhobhi Ghat Building, General Hospital Compound, Jalgaon – 425001
33.	Maharashtra	District Public Health Laboratory, 330/2, B, Y.P. Powar Nagar, Bendre Building, Kolhapur - 416002
34.	Maharashtra	Municipal Laboratory, Room No. 49, 2 nd Floor, G North Ward Office, J.K. Sawant Marg, Dadar, Dadar West, Mumbai-400 028
35.	Maharashtra	Room No. 606, Public Health Laboratory, Konkan Bhawan, 6th Floor, CBD Belapur, District Thane, New Mumbai - 400 614

36.	Maharashtra	District Public Health Laboratory, New Civil Hospital Compound, Nashik – 422 002
37.	Maharashtra	State Public Health Laboratory, Stavely Road, Cantonment Water Works Compound, Pulgate, Near St. Mary's School, Pune - 411001
38.	Maharashtra	District Public Health Laboratory, Vasantdada Co-op. Industrial Estate, Madhavnagar Road, Nr. R.T.O., Sangli – 416416
39.	Maharashtra	District Public Health Laboratory, Sai Darshan, 5 – Babanagar, Near Polytechnic College, Nanded - 431602
40.	Maharashtra	Regional Public Health Laboratory, Mental Hospital Compound, Chindwada Road, Nagpur- 440 029
41.	Maharashtra	District Public Health Laboratory, Opposite Irvin General Hospital, Amravati-444601
42.	Meghalaya	Combined Food and Drug Laboratory, Pasteur Institute, Shillong - 793001
43.	Nagaland	State Public Health Laboratory, Merhuliesta Colony, Near CMO Office, Kohima, Nagaland
44.	Odisha	State Public Health Laboratory, In front of Ram Mandir, Convent Square, Bhubaneswar - 751001
45.	Puducherry	Public Health Laboratory, Indira Nagar, Gorimedu, Puducherry – 605006
46.	Punjab	State Food, Drugs and Excise Laboratory, Govt. of Punjab, Second Floor, Sector – 11 D, Chandigarh
47.	Punjab	District Public Health, Laboratory, Nehru Garden, Jullundhar (Punjab)
48.	Punjab	District Public Health, Laboratory, Old Civil Hospital, Bhatinda (Punjab)
49.	Rajasthan	Food Safety and Standards Laboratory, E-1, Behind Kamla Nehru T.B. Hospital, Jaipur Road, Ajmer
50.	Rajasthan	State Public Health Laboratory, Mini Swasthya Bhawan, Mandir Marg, Sethi Colony, Behind Mental Hospital, Jaipur - 302004
51.	Rajasthan	Regional Public Health Laboratory, C-27, Railway Road, Jodhpur - 342001
52.	Rajasthan	Food Safety and Standards Laboratory, Rajiv Gandhi Hospital Campus, Alwar – 301001
53.	Rajasthan	Public Health Laboratory, Maharana Bhopal Cancer Hospital, Near Dhobighat, Udaipur
54.	Rajasthan	Public Health Laboratory, P.B.M. Hospital Premises, Bikaner (Rajasthan)
55.	Rajasthan	Public Health Laboratory, Sriganganagar (Rajasthan)
56.	Rajasthan	Public Health Laboratory, Banswara (Rajasthan)
57.	Tamil Nadu	Food Analysis Laboratory, No.219, Race Course Road, Coimbatore -641018

58.	Tamil Nadu	Food Analysis Laboratory, King Institute Campus, Guindy, Chennai -600032
59.	Tamil Nadu	Food Analysis Laboratory, Gandhi Nagaram, Near Gandhi Museum, Poor Home Campus, Madurai – 625 020
60.	Tamil Nadu	Food Analysis Laboratory, Kamaraj Nagar Colony Post, Salem - 636014
61.	Tamil Nadu	Food Analysis Laboratory, Medical College Road, Near Membalam, Thanjavur - 613001
62.	Tamil Nadu	Food Analysis Laboratory, No.5, Old Police Hospital Road, Palayamkottai, Tirunelveli – 627002
63.	Tamil Nadu	Food Analysis Laboratory, Corporation of Chennai, Chennai-600003
64.	Tripura	Regional Food Laboratory, Pandit Nehru Office Complex, Agartala - 799006
65.	Uttar Pradesh	Regional Public Analyst Laboratory, HB Training Campus, Halwai Ki Bageechi, Agra
66.	Uttar Pradesh	State Government Laboratory, UP Behind Nehru Batika, Sector C, Aliganj, Lucknow – 226020
67.	Uttar Pradesh	Regional Public Health Laboratory, Shivpur, Varanasi – 221003
68.	West Bengal	Public Health Laboratory, 2, Convent Road, Kolkata 700015
69.	West Bengal	Central Food Laboratory, Kolkata Municipal Corporation, I-A, Hogg Street,Kolkata 700087
70.	West Bengal	District Public Health Laboratory, Murshidabad, CMO Office Campus, P.O. Berhampur, Murshidabad (W.B.)
71.	West Bengal	Public Health Laboratory, GM Hospital, P.O. Netaji Subhash, Santorium,Kalyani-741 251, Nadia (W.B.)
72.	West Bengal	Assansol Mines Board of Health Laboratory, Asansol, District Burdwan-713304

5.4. GMP (Good manufacturing practices)

FSSAI has specified procedures and practices to be followed by food businesses to prevent the occurrence of food borne illnesses by actively controlling hazards throughout the food supply chain. Every food business operator is required to have a documented FSMS plan and to comply with Schedule IV of the FSS (Licensing and Registration of Food Businesses) Regulations 2011. Schedule IV introduces the concept of FSMS based on implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) by food businesses.

Technical Panels of eminent domain experts have been set up to review and update FSMS standards, draft and review Good Hygiene practices (GHP) and Good Manufacturing Practices (GMP) by food category, identify gaps if any and prescribe new schedules and process standards wherever required from time to time.

To provide assurance of food safety, Food businesses must implement an effective Food Safety

Management System (FSMS) based on Hazard Analysis and Critical Control Point (HACCP) and suitable pre- requisite programmes by actively controlling hazards throughout the food chain starting from food production till final consumption.

As per the condition of license under FSS (Licensing & Registration of Food Businesses) Regulations 2011, every food business operator (FBO) applying for licensing must have a documented FSMS plan and comply with schedule 4 of these regulations. Schedule 4 introduces the concept of FSMS based on implementation of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) by food businesses and is divided into two parts as under:

Part 1 - General hygienic and sanitary practices to be followed by food business operators applying for registration - Petty food operators (Food Safety & Standards (Licensing and Registration of food Business) Regulations, 2011.

- Every petty Food Business Operator shall register them with the Registering Authority by submitting an application for registration in Form A under Schedule 2 of FSSAI 2011 Regulations along with a fee as provided in Schedule 3.
- The petty food manufacturer shall follow the basic hygiene and safety requirements provided in Part I of Schedule 4 of these Regulations and provide a self-attested declaration of adherence to these requirements with the application in the format provided in Annexure-1 under Schedule 2.
- The Registering Authority shall consider the application and may either grant registration or reject it with reasons to be recorded in writing or issue notice for inspection, within 7 days of receipt of an application for registration.
- In the event of an inspection being ordered, the registration shall be granted by the Registering Authority after being satisfied with the safety, hygiene and sanitary conditions of the premises as contained in Part II of Schedule 4 within a period of 30 days.
- If registration is not granted, or denied, or inspection not ordered within 7 days as provided in above sub regulation (3) or no decision is communicated within 30 days as provided in above sub regulation (4), the petty food manufacturer may start its business, provided that it will be incumbent on the Food Business Operator to comply with any improvement suggested by the Registering Authority even later. Provided that registration shall not be refused without giving the applicant an opportunity of being heard and for reasons to be recorded in writing.
- The Registering Authority shall issue a registration certificate and a photo identity card, which shall be displayed at a prominent place at all times within the premises or vehicle or cart or any other place where the person carries on sale/manufacture of food in case of Petty Food Business.
- The Registering Authority or any officer or agency specifically authorized for this purpose shall carry out food safety inspection of the registered establishments at least once in a year.

Part 2 - General hygienic and sanitary practices to be followed by food business operators applying for license- Manufacturing/ processing/ packaging/storage/distribution.

As per Section 31(1) & 31(2) of FSS Act, 2006 every Food Business Operator in the country is required to be licensed/registered under the Food Safety &Standards Authority of India. The licensing and registration procedure and requirements are regulated by Food Safety & Standards (Licensing and Registration of food Business) Regulations, 2011. Registration is meant for petty food manufacturers that includes petty retailer, hawker, itinerant vendor or a temporary stall holder or small or cottage scale industry having annual turnover up to 12 lacs. All food businesses having income more than this limit are required to take a license. The document, based on the product category, can be used by the FBOs (food business operators) as per the operations applicable to them.

General Hygienic and Sanitary practices to be followed by Food Business operators

(Schedule 4)

The establishment in which food is being handled, processed, manufactured, stored, distributed by the food business operator whether holder of registration certificate or a license as per the norms laid down in these regulations and the persons handling them should conform to the sanitary and hygienic requirement, food safety measures and other standards as specified below. It shall also be deemed to be the responsibility of the food business operator to ensure adherence to necessary requirements. These are the basic - compulsory requirements for ensuring safety of the food manufactured in any premise and FBOs shall continuously try to improve the sanitary and hygienic conditions at the premises with a goal of attaining India HACCP standards within a - previously determined period.

FSSAI has issued a guidance document on Food Safety Management System (FSMS) to implement GMP (good manufacturing practices)/GHP (good hygiene practices) requirements for fruit and vegetable products. This document is applicable for food businesses involved in the fruit and vegetable sector, which includes; Thermally processed Fruits, vegetables, Vegetable Soups , Fruits Juices, Pulp/Puree, Fruit Nectars, pickles etc.

Some important regulations are given for general hygienic and sanitary practices to be followed by petty food business operators applying for registration (Regulation 2.1.1(2))

- The premises shall be located in a sanitary place and free from filthy surroundings and shall maintain overall hygienic environment. All new units shall set up away from environmentally polluted areas.
- The premises to conduct food business for manufacturing should have adequate space for manufacturing and storage to maintain overall hygienic environment.
- The premises shall be clean, adequately lighted and ventilated and sufficient free space for movement.
- Floors, Ceilings and walls must be maintained in a sound condition. They should be smooth and easy to clean with no flaking paint or plaster.
- The floor and skirted walls shall be washed as per requirement with an effective disinfectant

the premises shall be kept free from all insects.

- Continuous supply of potable water shall be ensured in the premises. In case of intermittent water supply, adequate storage arrangement for water used in food or washing shall be made.
- Equipment and machinery when employed shall be of such design which will permit easy cleaning. Arrangements for cleaning of containers, tables, working parts of machinery, etc. shall be provided.
- No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of food. (Copper or brass vessels shall have proper lining).
- All equipments shall be kept clean, washed, dried and stacked at the close of business to ensure freedom from growth of mould/ fungi and infestation.
- All equipments shall be placed well away from the walls to allow proper inspection

5.5. Good Hygiene Practices (GHP)

All practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

These include

- Suitable facility design and maintenance
- Thoughtful equipment design and maintenance
- Documentation that includes procedures, forms and manuals
- Process validation
- Corrective and preventive actions
- Control of non-conforming products
- Traceability
- Management of incidents and product recall
- Job training and competence
- Hygiene and sanitation
- Waste removal
- Pest control
- Chemical and physical product contamination control
- Prevention of cross contamination.
- Dispatch and transport
- Allergen management
- Product packaging and labelling
- Personal hygiene

- Internal audits for hygiene, food safety and quality

5.6. GLP (Good Laboratory Practices)

Good Laboratory Practice (GLP) was first introduced in New Zealand and Denmark in 1972

Why use GLPs?

Generating reproducible, accurate analytical results is important for laboratory success, but isn't necessarily easy to do.

- There are processes and tools that are critical components of successful laboratory quality assurance programs.
- In general many of the practices that lead to a successful quality assurance program are also required for general business success such as:
- good communication
- engaged employees
- management
- a strong training program
- a facility that supports work to be done in the lab.

An Overview on Good Food Laboratory Practices

A Good Laboratory Practice (GLP) process is an important component of all Quality Programs.

- It includes a set of principles that provides the framework within which the laboratory is planned, performed, monitored, reported and archived.
- It is applicable in all aspects of a laboratory including; implementing, validating and maintaining the laboratory compliance.

Elements of Good Laboratory Practice

Quality Assurance - Establishing Confidence in Reported Data.

- Standard Operating Procedures (SOP's)
- Statistical procedures for data evaluation
- Instrumentation validation
- Reagent/materials certification
- Analyst certification
- Laboratory facilities certification
- Specimen/Sample tracking
- Documentation and Maintenance of Records.

- Accountability.

Why use GLPs?

- Generating reproducible, accurate analytical results is important for laboratory success, but isn't necessarily easy to do.
- However, there are processes and tools that are critical components of successful laboratory quality assurance programs.
- In general many of the practices that lead to a successful quality assurance program are also required for general business success such as: good communication, engaged employees and management, a strong training program and a facility that supports the work to be done in the lab.

Scope of Good Food Laboratory Practices

These Guidelines specify the general requirements for the competence to carry out systematic sampling of food samples, conduct chemical, microbiological tests and testing of packaging materials to ascertain the quality of food. It covers the tests performed using standard methods, non-standard methods, and laboratory-developed methods. These Guidelines are applicable to all organizations performing tests to ascertain the quality of food material including packaging material.

Structure of food lab:

Personnel:

Personnel need to clearly understand the nature of the foods they are testing and reasons for testing when undertaking contract review and method selection.

The Management Structure:

An up-to-date chart showing the organizational structure and lines of responsibility of the laboratory is an important feature of the quality assurance programme and should appear in the Quality Assurance Manual. When the laboratory is part of a larger organization it may also be desirable to have a chart showing the management and operational relationships which control the input of work requested and the output of results from the laboratory, the overall picture of the laboratory and the resources available for it. The general staff structure is shown in Table 5.1.

Table 5.1: The staffing structure of a typical food testing laboratory is as follows:

Head of Laboratory			
Officer in-Charge (Chemistry section)	Officer in-Charge (Microbiology section)	Officer in-Charge (Biotechnology section)	Officer in-Charge (Administration section)

Team Leaders Technical Staff/Analyst Supporting staff	Team Leaders Technical Staff/Analyst Supporting staff	Team Leaders Technical Staff/Analyst Supporting staff	Secretarial staff Supporting staff

Infrastructure and Accommodation and Related requirements:

General Principles:

Facilities must allow the laboratory's work to proceed both effectively and safely. Laboratory design should reflect the general features of the work programme anticipated in the long-term (10-20 years) rather than the specific pattern of current work.

Design of the Laboratory:

Even though the final design of the laboratory is made by architects and engineers, the analytical staff should be involved in some of the decisions that will ultimately affect their working environment and conditions. The food control laboratory has several functions such as chemical analysis of foods for proximate composition, trace metals, additives, GM testing, nutrients and toxicants, some basic food microbiology analysis and product organoleptic evaluation.

General Considerations:

Laboratory layout should be devised with efficiency in mind. For example, the distances staff have to walk for the different steps of the analytical processes they undertake should be as short as possible, though bearing in mind that some procedures may have to be segregated from others for analytical and/or safety reasons.

The Chemical Laboratory:

From a quality assurance standpoint, the design features which are important are those which can lead to erroneous results or to "lost" work, leading to missed deadlines and cost overruns. Erroneous results can arise from test materials becoming contaminated (e.g. by dust) or by cross-contamination from another sample or from a standard. Whilst good working practices will usually control most situations satisfactorily, a design which provides complete segregation of trace analyses from highly concentrated formulations and from pure substances used in preparing analytical standards is virtually essential: the segregation must apply to all facilities for washing/cleaning equipment, washing and storage of glassware, use of protective clothing and even transfer of notebooks and records.

Equipment and Instruments:

The complexity of equipping a laboratory and the consequent delay in production of useful results should not be underestimated. In the early stages, the requirements for equipment may seem large and complex but once the laboratory is established, the running costs are relatively low. Some of the instruments and equipment needed for chemical analysis by a modern food control

laboratory are: (for purposes of this listing, 'instruments' are measuring devices and 'equipment' are processing devices. Apparatus made primarily of glass are not included).

Instruments:

- Analytical Balance
- pH meter
- Spectrophotometer, UV-visible, double-beam
- Spectrophotometer, atomic absorption
- High Performance Liquid Chromatograph (with UV and differential refractive index
- detectors)
- Gas Chromatograph (with flame ionization and electron capture detectors)

Equipment:

- Blender
- Grinder
- Pulverizing hammer mill
- Air oven, forced draft
- Vacuum oven, with pump
- Muffle furnace
- Centrifuge
- Refrigerator
- Freezer
- Heaters and hotplates
- Steam and water baths
- Water distillation still or deionizer

Utilities:

Electricity must either be a stable supply, or the voltage must be stabilized by either one large stabilizer for the whole laboratory, or by a unit for each of the instruments requiring it. The lab should have sufficient number of electrical sockets. There must be several cold water taps per bench to allow for rinsing, condensers, etc., but hot water can be restricted to those sinks where apparatus is washed. In a larger laboratory a distribution system for distilled or deionized water would be advantageous. Fume hoods should have adequate provision for water taps, compressed air valves, electrical sockets etc.

Environment conditions, safety and related requirements:

Environmental Control:

Adequate control of temperature, humidity and dust is important to staff comfort, instrumental performance and safe working (e.g. with flammable solvents). If they are to perform properly optical instruments often require stable temperature conditions. Electronic equipment may have prescribed operating ranges for environmental temperature and humidity. Computers may need to be protected from strong magnetic fields from other equipment; any staff or visitors with heart pace-makers must avoid such fields. Cooling water, either from mains supplies or localised refrigeration may be necessary for the proper functioning of some equipment. Test materials, reagents, standards may need to be stored under controlled conditions. Some substances are affected by sunlight or fluorescent lights and must be protected from it. Delicate balances and optical instruments may need to be protected from vibration (e.g. from blenders, shakers and centrifuges) or may even need stabilised supports. All these needs have to be identified and documented so that proper procedures for monitoring them and taking necessary action can be included in the quality assurance system.

Records will be needed which show that: samples are received, stored, handled and analysed under environmental conditions that will not adversely affect analyses; temperature, humidity and light controls are adequate in sensitive areas to protect samples, extracts from them, personnel and equipment; the results of environmental sampling in laboratory areas are recorded; these should include records of air-flow rates across fume cupboard apertures.

Housekeeping Control:

As with any other aspect of the laboratory's activities, the responsibility for housekeeping activities must be clearly defined. Cleaning staff and laboratory staff must each have clear instructions as to their respective duties in relation to:

- cleaning of floors, vertical surfaces (e.g. cupboards, walls, windows and doors),
- horizontal surfaces (e.g. work surfaces, shelves), equipment, interiors of refrigerators, freezers, fume cupboards, controlled environment stores
- control of the contents of refrigerators, freezers, fume cupboards, controlled environment stores
- checking the performance of air-conditioning and dust extraction equipment and fume-cupboards
- pest control

The quality assurance programme will include work schedules, records of observations and of action required/taken covering housekeeping activities of this nature.

Safety Features:

The building and laboratory design should include a number of safety features including:

a) The fire areas of corridors should be formed of concrete blocks.

b) Services should include a shower sprinkler system near each doorway so that a worker can take an immediate shower, clothes and all, in the case of accidental general contact with corrosive or poisonous liquids or fire.

c) There should be built-in eye wash fountains or at least portable eyewash stations (obtainable from most chemical supply firms).

d) The traffic flow, the egress pattern and the proportions of the laboratory are all safety considerations. It must always be possible to leave the laboratory safely irrespective of the initial site of a fire. Serious thought must be given to the number and location of fire extinguishers and stand pipe systems, and to the availability of sprinkler systems.

e) Laboratories should be well-lit so that the operator does not have to peer too closely over potentially hazardous material in order to see what he is doing. There should be ample working space and bench tops and other surfaces should be kept clear of all material except that in current use.

f) Benches are best without shelves, only services, these being operated from the front so that the operator does not have to stretch across the bench. It is still common to see reagents on shelving at the back of benches (or above the centre of double-width benches) but it is probably safer if such reagents can be kept on side.

g) Shelve or in trays which are brought to the bench as required.

h) Flooring needs to be of a non – slip material, resistant to acids and solvents, but not so hard as to be tiring to stand on for a few hours at a time. No material is entirely satisfactory. Well-laid linoleum and a filled epoxy resin on top of concrete are among the best available. It is advisable not to polish laboratory floors.

i) Pollutants generated within the laboratory must be removed safely, quickly and efficiently. In particular, toxic or noxious gases must be removed expeditiously through a duct system that does not exhaust near the building air conditioning intake.

j) The building must be planned for security. Restriction of access is of considerable importance because of the extremely valuable and sensitive equipment used in the laboratory work as well as to protect the integrity of official samples.

k) It is very advisable to have an efficient fire and smoke detection system with appropriate alarms. Common fire detection equipment is usually either rate-of- temperature-rise or fixed-temperature detector using a substance of known melting point. There are advantages (and disadvantages) to each type of detector and the laboratory Head should select the one he feels best fits his laboratory.

Designing a laboratory to afford protection against every kind of hazard should be aimed at, but, the level of safety for the most general applications and to provide supplementary systems in areas of higher hazard has to be achieved.

A safe solvent storage area is ideally separate from the laboratory building in a stand- alone

structure. It can be a small building of one room and some possible design features are:

a) Construction of cement blocks or bricks.

b) For a stand-alone building, double walls with insulation between. The exterior wall can be material other than block or brick.

c) An epoxy film to cover the entire floor plus 10 cm up the base of the walls. (Any solvent spillage will pool and evaporate, rather than soak through the floors or walls.)

d) A copper pipe (about 25 mm) inside the room, which goes through the floor and is embedded about 2 m in earth. All metal objects in the room are to be attached to the pipe using heavy guage single strand copper wire. Also, attach a short wire with an alligator clip.

e) Storage shelves of metal and connected by wire to each other and the grounding pipe.

f) Air conditioning is external, with the entrance duct at the top of one corner of the room and the exit duct at the base of the opposite corner.

g) The door is of metal and fire-rated for at least one hour, with a positive closure. It must seal well when closed. The door sill is at least 10cm high.

h) Air conditioner exits duct with a fire baffle (to prevent flashback) and ducted to exit in the outside air at building roof height.

i) An extinguisher system, which should be carbon dioxide or Freon type and not water sprinklers.

Personnel related requirements:

1) Qualification for doing specific tasks shall be judged on the basis of their education, training, specific experience and demonstrated skill.

2) The personnel should be technically competent to perform their duties as allotted to them whether operating on specific equipments / performing tests /evaluating results/signing the reports.

3) Regular and refresher training should be organized to keep the personnel update in their domain of activity.

4) Specific job description for each personnel should be defined with their role and responsibility.

5) Personnel should wear proper uniform and protective clothing's, etc as required depending upon the test method.

6) While doing test no phone calls/ cell calls should be attended to avoid any type hazards and carelessness while performing the test.

7) Normally blank determination along with the known-standards must be carried out in duplicate/replicate to check the accuracy of the results obtained and human error etc.

8) All the analysis records must be documented either through hardcopy or through soft copy to demonstrate that the tests are really been carried out.

9) Random checking of the result should be done inter-laboratory and intra- laboratory to check the proficiency of the personnel.

10) In case of hazardous analysis, special precautions as provided in the methods should be taken for self and surroundings.

11) While opening and closing the laboratory room, safety precaution should be taken care of depending upon the nature of the laboratory, equipment and test method. Special care should be taken for microbiological lab. Instructions in this regard must be displayed in the lab.

12) In case of contractual appointment, technical competency of the personnel should be judged and they should be put on job only after they are trained and their competency in the respective field is established.

13) Alternative arrangement of personnel should exist in case one is not available but not at the cost of their technical competency.

14) Personnel should be medically fit depending upon the test method he is deployed to avoid any hazards.

15) Special precaution should be taken by the personnel during break time to ensure that tests are carried out as per prescribed method and no relaxation is given in the test method.

16) Calculation should be rechecked on random basis by the supervisor.

17) Daily wages should not be put to job.

18) The personnel at the time of working in the laboratory should be alert and concentrate on their work only.

- Supervisory officer should randomly watch the analysis activity and guide from t ime to time to increase the competency of analyst.

19) Eating habits should be avoided in the laboratory.

20) First Aid box should be available in the lab. along with emergency Telephone no. of hospital/ doctors/contact person.

21) During odd times person should avoid working lonely.

22) Fuming chamber must be used for test requiring ash, protein determination, evaporation of solvents etc.

23) While pouring down acids etc in the basin, water taps should be kept on slowly.

24) Electrical equipments should be handled with great care.

25) Poisonous and hazardous chemicals must be kept under safe custody.

26) Manual sucking from mouth of liquid should be done with bulb type pipette.

- Competency of the personnel should be judged regularly by giving unknown

samples.

27) No external or internal pressure should be put on analyst.

- Output should not be linked with quantum of work. More emphasis should be on quality output or results.

Test methods:

1) The laboratory shall use only official methods depending on the requirement of the test, its sensitivity and nature of the commodity which is being tested and quality/safety factors to be determined.

2) In case of non-official method, validation of the methods as per set norms is a must and their range of detection/quantification, L.O.D./L.O.Q. limitations etc. must be established.

3) Selection of method is very important depending upon the requirement of the test and customer requirement.

4) Estimation of uncertainty of measurement should be available for each method in context of the food commodity and test to be done.

5) External calibration of the equipment is a must annually or depending upon its use. However, in case of any equipment being used very frequently, internal calibration facility should be available and done regularly with a record thereof.

6) Glass apparatus should be calibrated.

7) In case of standard chemicals required in testing, whose purity can alter the result should be certified reference material with proper traceability.

8) In case of recovery and PPM level extraction from a food commodity, percentage recovery must be established for each food and the contaminant/constituent which have to be determined and the calculation should take care of such recovery.

9) Sometimes official methods do not prescribe the interfering material in the test method, limitations, its sensitivity, range of detection and qualification, capability of the equipments being used, due to change of the sophisticated equipment as prescribed in the method for a particular model/ technology. Hence it is necessary to establish the suitability of such methods for their particular test and equipment, etc before giving the results. Obviously the method needs to be validated internally for its particular use using particular equipment.

10) Standard solution/CRM Solution should be stored at required temperature and condition and its strength should be checked regularly and record thereof should be maintained.

11) Calculation should be done and rounded off while reporting the results to the required level of standard.

12) SOP as far as possible should be available for test method along with the protocol.

13) Method should be available while performing any test to follow exactly the test method prescribed. No short cuts should be followed and tests should not be done on a memory basis alone.

14) Purity of the solvents, water being used and other chemicals should be checked regularly and a record thereof should be maintained.

15) In case of any controversy or marginal results, only reference methods should be used.

16) In case of micro biological analysis standard culture must be available to establish the confirmation of the microbes. SWAB testing must be done for inoculation room and media preparation room regularly to ensure that it is not contaminated.

17) The results should be recorded commensurating with the calibration of the glass apparatus etc e.g. in case of a burette, the result should be reported only to the displayed capabilities of the burette.

18) Special precaution should be taken for pipetting and ejecting the solution from the pipette. The solution should not be blown by air through mouth.

19) All the apparatuses specially glass should be contamination free and should be cleaned and rinsed thoroughly before use. No chemicals should be used after its expiry or otherwise if it looks like deteriorated or decomposed.

Equipments:

1) All the equipments being used should be under permanent control of the laboratory and should be capable of in context of the test method.

2) The equipment must be calibrated depending upon the requirements by an outside accredited lab and/or internally as the case maybe.

3) In case the sophisticated instruments are shifted from one place to another the same should be re-calibrated.

4) Depending upon the uses, the equipments should be internally calibrated either daily or at a periodically interval as the case maybe.

5) Instruction manual, operation manual and other details of the equipments like calibration, due date of calibration, safety precaution, etc must be available at the side of the equipment.

6) Each equipment should be uniquely identifiable.

7) The equipment should be placed and test must be performed under a proper environmental condition as prescribed. Normally the room should be dust-free, air conditioned with controlled humidity. Special condition needs to be followed in case of equipment being used in case of micro biological analysis like Air handling unit, etc.

8) Each sophisticated equipment should have IQ, OQ and PQ Certificate from the manufacturer.

9) LOD/LOQ/ Range of detection/ range of quantification must be established for each equipment in context of the test method, nature of the food commodity, constituent to be determined. The reason being that normally in official methods, the model of the equipment being used along with its accessories becomes old whereas due to technological advancement a model of the equipments are upgraded along with accessories and software, hence the LOD, LOQ, etc must be established and should be checked as claimed by the manufacturer which may not commensurate with the limits given in the official methods. SOP must be

available for operation.

10) Equipments not working should be placed under a tag "out of order"

11) Software being used in the equipment must be validated and a record thereof should be available.

12) Maintenance plan of the equipment should be available and should be done under annual maintenance contract.

i. Equipments should not be subjected to overloading or mishandling which could give erroneous results.

ii. In case the equipment is sent outside the laboratory for repair, etc. proper procedure of packing and transportation as prescribed by the manufacturer should be followed.

iii. Intermediate checks of the equipments must be done through known and certified standards regularly. The equipment should be handled by technically competent and trained personnel only. Such personnel should be trained on routine maintenance and minor repair of the equipments.

iv. Proper procedure as prescribed by the manufacturer should be followed for cleaning of the equipments and its accessories before and after use.

v. The SOP for safe handling, transportation, storage, use and plant maintenance of the equipments must be available to ensure proper functioning and to prevent deterioration/contamination.

vi. Do and don'ts regarding important instruction should be available along with side of the equipments and should be visible all the time.

vii. Due care should be taken to ensure constant voltage supply of electricity as required for the equipment to avoid fluctuation and thus variation in results.

viii. After return of the equipment from repair, the same procedure should be followed as that for new equipment to ensure that the results rendered by the equipments are as per capability of the equipment. In such cases the instruments need to be recalibrated before put to use.

ix. Equipments where gases are being used, the purity of the gas should be as per requirement of the equipment/test method.

x. Gas cylinders should be put outside the laboratory room at a well secured and approachable place.

xi. Temperature and humidity of the room where the equipments are placed must be recorded daily. In case of micro biological laboratory, special precaution should be taken as per requirement of the test method for environmental conditions especially in case of isolation and determination of pathogens.

xii. In case of a mobile food testing laboratory a separate SOP should be available and the equipments used in such laboratory should be technologically sturdy to avoid variation in results.

xiii. Calibration of such equipments needs to be done very frequently preferable daily before being put to use.

xiv. Software being used in the equipment should be capable of achieving the accuracy required and should be complied with the specification related to the test method.

xv. Software should be upgraded and validated from time to time.

xvi. Obsolete equipments giving erroneous results in context of the requirement of the test method should not be put touse.

xvii. The equipment should be placed on a vibration free platform.

xviii. Daily cleaning of the equipment should be done by trained personnel as per SOP

xix. Proper safety precautions should be taken for equipments running round the clock in the absence of the personnel.

Certified reference materials/ standards and reference cultures:

Testing, validation/calibration, standardization & reference materials are inter-related due to dependent on each other. Without proper reference materials, it is not possible to make up any idealized and reliable measurement system. As per the lab quality assurance procedure reference materials are required for all types of testing and validation/calibration. These are widely used for validation/calibration of an apparatus and testing procedure, assessing the true value.

The reference materials are generally used for, to develop and validate accurate method of analysis ensuring traceable measurement results at the working level, to calibrate measurement system and to demonstrate the accuracy of results, assure the long term adequacy and integrity of measurement quality assurance programme and monitor the lab performance, use in inter laboratory comparison and proficiency testing programme.

The laboratory shall ensure to maintain the reference standards, which are certified by the competent body having traceability to a national/international system like NIST etc. The certificate provided by the supplier/manufacturer shall be maintained in the laboratory for records.

The reference standards having high purity, critical characteristics and require to store in special condition and hence its, to be stored in appropriate special condition as per the requirements. The substances are to be kept in sealed vial and shall be stored in dry place, away from heat, sunlight & moisture.

The reference material of various parameters such as metals, pesticides, antibiotics, volumetric standards etc. may be received from standard brand like Sigma, Aldrich, Fluka, Riedel-de-Haen, Dr. EhrenstroferGmbh, Merck, Supelco etc. in regular intervals accompanying with certificates with proper label. The certificates shall include the name of the standard, the purity, uncertainty at a stated level of confidence, expiry/ validity/ shelf life, QC release, chemical formula / structure, assay/potency level of confidence / chromatogram, storage condition etc. The same shall be verified for the label, certificate & condition during receiving of thestandards.

The reference standard solutions are required for sample analysis, quantification and QC checks. The laboratory shall be prepared the standard solution as needed like stock / primary, intermediate & working solution and wherever applicable the purity shall be considered during preparation. The standard solutions shall be kept in screw capped glass vials, standard volumetric flasks/stoppered conical flask (transparent/amber coloured) in air conditioned room / refrigerate /deep freezer depending upon storage condition & requirements.

The standards shall be prepared from bulk reference standard materials received from the market as A grade material. The selection criteria for the bulk material intended to accept as working standard in assay and purity of substances. For accepting the material to be taken as working standard the molecule must be subjected to chemical characterization. First the standard stock solution to be prepared from which different working standard is made. The preparation of standards is generally carried out in regular interval as per the requirement / laboratory protocol and the records of those are to be maintained and labelled with concentration & date of preparation.

The preparation of working standard is generally carried out during analysis/ whenever necessary and records of these are to be maintained.

The intermediate checks of the standards shall be checked in regular interval to ensure the performance, stability & integrity of the standards and records of those are maintained with

Quality Control Chart / Levey-Jennings Chart etc.

The shelf life / expiration date declared by the reference standards providing organization is generally applied to unopened condition that have to store at recommended temperature. Hence it is the responsibility of the laboratory to maintain the critical characterization, performance, stability & integrity of the standards through proper handling, storage etc. & same shall be ensured by the intermediate checks in regular interval / as per the laboratory protocol.

For some reference standards the shelf life / expiration date may not declared by the reference standards providing organization, in those cases the following shelf life may be considered when the standards are stored un opened at recommended temperature

1. Room temperature items, which are not temperature sensitive and usually are stabled for five years from the date of receipt.
2. Refrigerated items usually are stabled for two years from the date of receipt.
3. Freezer items usually are stabled for one year from the date of receipt

However it is the primary responsibilities of the laboratory to ensure the performance, stability & integrity of the standards through intermediate checks in regular interval / as per the laboratory protocol.

Reagent solution/standard solutions shall be prepared in established manner, for preparation of reagents the testing personnel refers to be relevant reference. After their preparation, those are to be stored in appropriate storage condition i.e. protected from light, tightly stoppered, refrigerated

etc. Wherever, it is recommended reagents are to be prepared freshly. All the reagents/solutions bottles shall be properly labelled with name, date of preparation, concentration etc.

All reference standards shall be kept under responsible person to maintain proper storage, transport, security, integrity, mishandling etc and the relevant records are also to be maintained. The utmost care & protection shall be taken during handling & preparation of standards to avoid cross contamination & health hazard.

The reference culture/microbial pure cultures are used establishing acceptable performance of media, performance of the kits, validation of methods and assessing/evaluating the laboratory performance. The reference microbial strains are directly collected by laboratory from recognized national or international collection (ATCC, MTCC, NCIM etc) with traceability. Generally the reference strains are received in lyophilized stage or deep-frozen stage. If the reference strain has been thawed they shall not be refrozen.

The reference microbial stains are used for Quality control; internal quality control and performance of culture media in terms of productivity, selectivity, performance evaluation and interpretation of result. The reference cultures are received either on slant form or in lyophilized forms in vials.

On receipt the reference cultures, requires to revive in the laboratory. The active cultures shall be sub-cultured on to recommended medium and incubated at temperature specified. For lyophilized culture the outer surface of the vials is disinfected, wrapped with thick cotton wool and neck of the culture vials is broken. The contents transfer into 3 to 5 ml of recommended broth medium and mixed properly. The suspension is to streak on the recommended agar plate and incubates at specified temperature. Reference cultures to be checked for its purity, homogeneity, and typical morphology. Subsequently they have to check for characteristic reaction in selective medium and biochemical reactions. Whenever necessary, serological test as per analytical procedure is also to be carried out to check the pure culture.

Sub-culturing from original stock in regular intervals as working culture for routine use and records to be maintained. The intermediate checks on the purity and biochemical characterization also to be checked. All the working cultures are properly locate with name, date etc. & to be kept under proper storage condition.

All reference standards / pure culture stains are to be kept under responsible person to maintain proper storage, transport, security, integrity, mishandling etc and the relevant records are also to be maintained. The utmost care & protection shall be taken during handling of microbial pure cultures for to avoid cross contamination & health hazard. The laboratory has to maintain procedures / instruction for all.

Calibration and performance assessment related requirements:

For accurate test results, lab shall be ensured that the equipments which are suitable for intended purpose and capable of providing valid results, such instruments would be regularly inspected, checked & calibrated accordingly. So laboratory should establish a schedule for the calibration and

performance verification of equipments/instruments, which will be direct influence on the test results.

The calibrations to be done by in-house (internal)/external agencies/competent body having traceability to a national / international standard (NABL accredited lab) depending upon the type of equipment / instruments.

Purchase of consumables/ equipments:

The laboratory should maintain a proper system for purchase service & supplies of all media, chemical, reagents & other requirements/appliance, consumables to avoid undesirable, unconfirmed supplies of them and also ensure there should not be any effect on the of test analysis /result. Requirements like name of the chemicals, appliances, glassware's, consumables, brand name, quantity, Management, rate contract/ comparative quotation, quantity available in stock shall be well documented by the laboratory.

Sampling & sample handling:

Sampling for testing or analysis is a process of taking a representative portion from a material or product to test (e.g. by physical measurements, chemical analysis, microbiological examination), typically for the purposes of identification, quality control, or regulatory assessment. The sampling is a significant role in testing activities as it reflects the ultimate test results.

It is not mandatory that all the laboratories shall be involved in sampling activities. However, the laboratory involves in sampling shall maintain at least the following

The laboratory policy & declaration on sampling:

The laboratory should have authorized personnel / sampler with adequate knowledge, training etc on sampling. The laboratory shall maintain the sampling plan & procedure in respects of the products / materials that shall include selection, withdrawn & preparation of samples during sampling. The same shall be based on appropriate statistical method / regulatory guidelines / references. Work instruction shall be maintained for the personnel involve in sampling activities.

The laboratory should have all facilities like tools, equipments / instruments etc requires for various sampling. The laboratory shall maintain the relevant data & operation related to sampling, procedure use, location, date / time of sampling, identification of sampler, other specific requirements like environmental conditions, transportation, statistics the sampling procedures are based upon etc and documents shall be maintained.

All incoming samples shall receive through the receiving section maintained and supervised by laboratory responsible person. The laboratory shall maintain a system on traceability of all accepted samples and the same shall be maintained throughout the retention of the sample in the laboratory without any confusion.

The laboratory should ensure to maintain a proper documented system procedure for handling of test items including sample receiving, storage, transportation, retention / disposal, integrity,

avoid and prevent loss/damage of the test samples.

General Principles:

The identity, homogeneity and integrity of the materials being handled by the laboratory must be ensured throughout the time they are under the control of the laboratory e.g. from sample receipt to data report and authorized disposal of the surplus material. The analytical data report must reflect the composition of the received material as a whole.

The sampling procedure should describe the selection, sampling plan, withdrawal or preparation of sample from a substance, material or product to yield the required information. If the customer requires deviations, additions or exclusions from the documented sampling procedure, these shall be recorded in detail with appropriate sampling data and shall be included in all documents containing test and /or calibration results.

The laboratory shall have the procedure for recording relevant data and operations relating to sampling that forms part of the testing and calibrations that is undertaken. These records shall include the sampling procedure used, the Identification of the sampler, environmental conditions (if relevant) and diagrams and other equivalent means to identify the sampling location as necessary.

Samples may be conveniently classified under two broad divisions:

a) Formal samples –These are samples taken to determine if the food complies with national or local laws or regulations and

b) Informal Samples –These are samples taken for the purpose of monitoring or as part of survey work.

Formal follow-up samples can be taken if informal samples receive adverse laboratory reports. Formal or informal sample are also taken under others such as follow-up to a consumer complaint.

Control and Storage:

The storage of test materials is of major importance if the analytical data produced is to reflect and be traceable to the original sample. Deterioration of test materials invalidates any results. Therefore; test materials must be stored so as to ensure their integrity, safety, legality and stability. The laboratory must guard against deterioration, contamination and loss of identity. Special care will be needed where trace analysis is involved in order to ensure that extraneous materials do not contaminate the test materials and equipment.

There are three basic forms of storage - room temperature (dry room), refrigeration and freezing. The QA programme should specify the conditions to be used. There are also problems associated with the type of container in which food can be stored. Foods that contain fats and oils should not be stored in copper or metallic vessels and foods that easily desiccate such as fruits need to be stored in ways, which avoid loss of water.

The Analytical Sample (Test Portion):

Before removing the test portion (s) for analysis, the analyst must be certain that all records are in order, integrity has been maintained containers are intact and sealed (if any), unbroken.

Any ambiguity in the analytical requirement must be resolved, e.g. with canned pickle in oil, is the analysis to be done on the pickle, oil or the whole contents of the can.

For analysis, the analyst first removes a test portion. If the test material comprises more than one item (fruit, vegetable etc.) the test portion should contain material from each item – usually achieved by comminuting a number of items and removing a portion. After the test portion has been removed, the remaining test material is returned to the storage.

Referral of the Test Material:

On occasions it may be necessary to pass a test material to another laboratory for some specialized analysis or because of some analytical facility not being available with the laboratory or because of overload of work. Unless the other laboratory is a part of the same QA programme or the two laboratories are accredited by the same (or equivalent schemes), this referral would mean that the test portion sent for that analysis ceases to be quality assured by the parent laboratory. This should be made clear in the analysis report to the customer.

Test Material Disposal:

Sample disposal is relatively a simple matter. The only problem arrives when there is a hazard involved in the destruction or the sample remains must have specific treatment e.g. a sample of groundnut heavily contaminated with alfatoxin. Any residual material if valuable such as flavouring concentrate maybe required to be returned to the originator. The register should therefore have a column in it for details of when, how and where the test material was disposed.

Documentation for QA Programme:

- Register for sample receipt: Test material identification
- Flow chart of the sample submitted for laboratory examination
- Storage conditions for food test materials

5.7. HACCP implementation program

During implementation of HACCP, it is imperative to set controls at each point of the production line at which safety problems (physical, chemical and microbiological) are likely to occur. A HACCP plan is required to be in place before initiating the HACCP system. HACCP is a system which identifies specific hazard(s) (i.e. any biological, chemical, or physical property that adversely affects the safety of the food) and specifies measures for their control. A HACCP Plan consists of 5 initial steps and 7major HACCP principles.

Risk Assessment

Risk assessment is a critical step in a HACCP plan. Risk is the combination of the likelihood (probability) of Occurrence & Consequence(s) (sometimes referred as severity) of a specified

hazardous event occurring.

So the risk is defined as:

RISK = OCCURRENCE * CONSEQUENCE

The following scales can be used for the measurement of the likelihood of Occurrence & the consequences; hence the risk as well.

Criteria for Likelihood of Occurrence				
Likelihood of Occurrence	Criteria			Rating
	Frequency of occurring at least once in		Description	
	Routine job	Irregular job		
Very High	Daily	5 batches	Persistent, will occur if not attended to	5
High	Fortnightly	50 batches	Frequent chance of occurrence	4
Moderate	Monthly	100 batches	Occasionally could occur	3
Low	Yearly	1000 batches	Relatively some chance of occurrence	2
Remote	In 5 years	5000 batches	Unlikely to occur	1

There are five steps in HACCP.

1. Assemble HACCP team
2. Describe the product
3. Document intended use of product
4. Construct process flow diagram
5. Onsite confirmation of flow diagram

Seven principles are involved in HACCP.

1. Identify Hazards (Conduct Hazard Analysis)
2. Identify CCP's (Critical Control Points)
3. Establish critical limits for each CCP
4. Establish monitoring action
5. Establish corrective action
6. Establish verification process
7. Establish record keeping procedure.

Consequence (Severity)		
Rating	Severity	Effect
5	Very High (Catastrophic)	Death
4	High (Critical)	Serious illness

3	Moderate	Illness/Injuries
2	Low	Uncomfort
1	Remote	No injuries

Nature of Control over Risk

Rank of Risk	Risk Index Value	Level of Control	Significant
R1	16-25	Avoidance/Special Process	Significant Hazard
R2	9-15	Physical Control/ Monitoring	Significant Hazard
R3	5-8	Formal Control	Non-Significant Hazard
R4	0-4	Informal Control / Training	Non-Significant Hazard

The level of risk could help to identify the level of control as per the following:

R1: Avoidance:	Precluding the possibility of a given hazard, it may be the modification of the process if necessary.
R2: Physical Control:	Continuous control & monitoring of the actual physical process.
R3: Formal Control:	It is the management of the conditions of an operation to maintain compliance with documented criteria.
R4: Informal Control and Training:	It is the monitoring/check of the process without formal recording.
	It is the teaching of the staff responsible for the process about what is to be done in order to prevent the hazard.

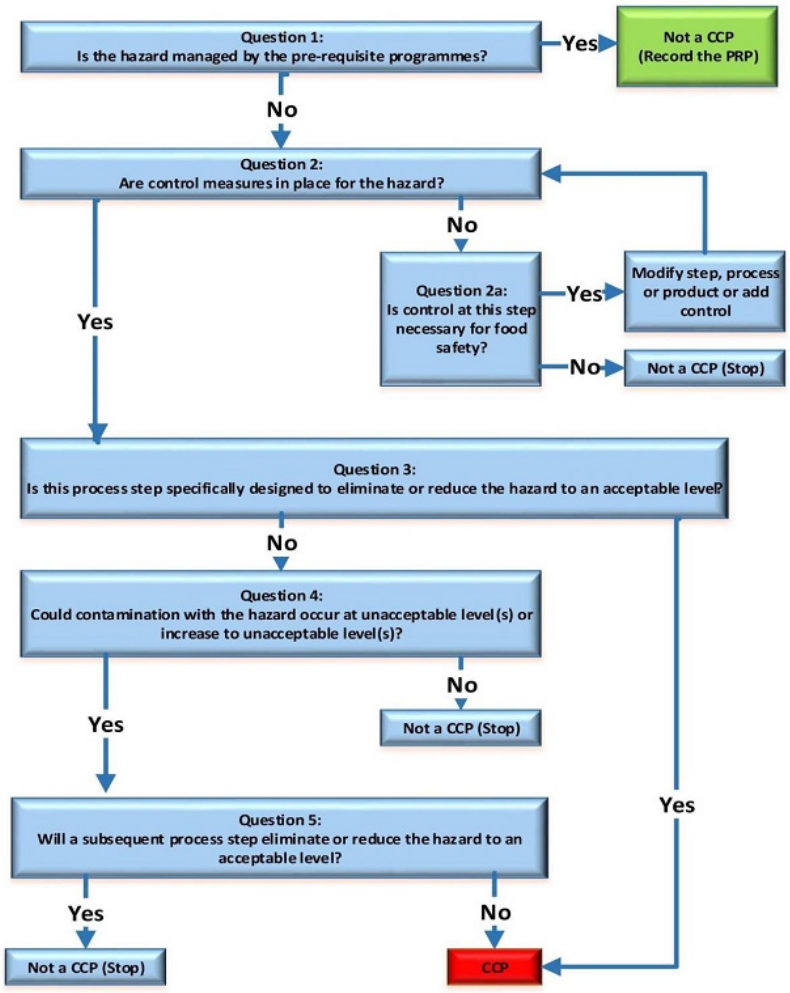
Below is a template to determine what severity and probability a processing step is involved with and therefore what level of criticality is holds in the processing line.

			Consequence/Severity				
			How severe could the outcome be if the risk even to				
			Severe	Major	Significant	Minor	Insignificant
Probability / Likelihood	What's the risk of the ch ance occurring?	Frequent	Extreme	Extreme	Very High	High	Medium
		Likely	Extreme	Very High	High	Medium	Medium
		Occasional	Very High	High	Medium	Medium	Low
		Seldom	High	Medium	Medium	Low	Very Low
		Unlikely	Medium	Medium	Low	Very Low	Very Low

Decision Tree

Hazard Analysis and Critical Control Point (HACCP) decision trees are tools that can be used to help you decide whether a hazard control point is a critical control point (CCP) or not. A CCP is a step at which control can be applied. However, it is not always possible to eliminate or prevent a food safety hazard, so this allows you to reduce it to an acceptable level.

The purpose of a decision tree is to support the judgment of the team and help you to confirm whether the hazard needs more food safety controls. Decision trees are not mandatory elements of HACCP but they can be useful in helping you determine whether a particular step is a CCP. It is vital that you determine the correct CCPs to ensure that food is managed effectively and safely. The number of CCPs in a process will depend on how complex the process is and how many hazards are present.



5.8. Food Quality and Safety Standards related to Coconut

Quality is a key issue in any kind of food processing operation. There are many reports dealing with quality related problems of coconut kernel industry, mainly copra processing. Copra processed improperly under unhygienic conditions could be susceptible to microbial invasion, insects and microbes. In addition, there are health related safety issues associated with these problems, mainly, aflatoxin in copra which is produced by Aspergillus flavus and is carcinogenic and may adversely affect human and animal health (Jayasinghe et al., 2007).

Quality of copra

The quality of milling copra ultimately determines the quality of the oil and the residual cake. The quality of copra is influenced by i) moisture content ii) colour and cleanliness iii) microbial load iv) rubberiness v) case hardening and vi) charring.

Moisture is the most important factor influencing the quality of copra. Copra with a moisture content of less than six percent is considered as good quality since it is not easily damaged by insects, moulds or microorganisms. At ICAR-CPCRI, Kasaragod developed an electronic moisture meter to determine the moisture content of copra (Madhavan and Bosco, 2004), based on the electrical conductivity of the kernel. The instrument can read moisture content from 5 to 40%. It is very handy and the accuracy is more than 94 percent in the lower levels of moisture content readings.

Nuts from dwarf variety palms, unripe nuts as well as those from sulphur deficient palms yield rubbery copra. This copra undergoes rapid deterioration and good copra also becomes susceptible to microbial infestation when mixed with rubbery copra (Southern, 1957). Case hardening of copra is seen when nuts are dried in kilns and hot air dryers with no temperature control. If the initial drying temperature is too high, case hardening can occur, preventing the moisture from the interior of the meat from diffusing rapidly to the outside layers. Case hardened copra develops a hard smooth surface covering a wet core. While drying copra, the temperature should not exceed 70°C in the early stages and 60°C subsequently, which will otherwise result in charring. The oil from charred copra will be turbid with a burnt odour.

Bio deterioration of copra

Defective methods of processing and high moisture content of copra are the major factors responsible for copra deterioration. Coconut kernel is a favourable substrate for the growth of microorganisms. If drying is done under open conditions, copra spoilage due to fungal infection is very common. Usually bacterial action starts during the initial stages of drying and later mould infection occurs. A gap of more than four hours between splitting and drying facilitates the activities of bacteria. With relative humidity of 80 per cent at temperatures above 30°C, bacteria rapidly multiply within four hours; a surface slime begins to develop on the wet kernel. The slime continues to develop and it becomes more pronounced during the first and second days of drying. The bacteria are active at moisture levels above 20 per cent. As a result of the bacterial growth, the copra looses white colour, turns red and becomes slimy. Serratia marscessens, Staphyloccus aureus and Bacillus sp., are the common bacteria, which cause discolouration, sliminess and softening of the copra (Rethinam and Bosco, 2006).

The penetrating moulds make their appearance after the bacterial growth. Rhizopus sp., or the white mould thrives on wet meat and destroys a very high percentage of oil and the oil from the infected kernel has a high percentage of free fatty acid. Aspergillus niger or black mould has a lower moisture requirement. This mould causes considerable loss of oil up to 40 per cent. The Aspergillus flavus group or brown mould is the most serious of all moulds. It flourishes at 8 - 12 per cent of moisture and the oil loss in this case also may be more than 40 per cent. It causes maximum colour change and rancidity in the oil. The Penicillum glaucum group or the green mould is commonly

found on copra and grows well on the copra with moisture content of six per cent. This fungus do not penetrate deeper and causes minimum reduction in oil content. In addition to these only two mentioned other fungi, Mucor hiemalis and Aspergillus tamarii (yellow mould) are often found on copra and cause considerable loss. Pure coconut oil is not a suitable medium for the growth of microorganisms. Moulds produce free fatty acid in the copra and bacteria cause decomposition of albumin in the moist copra. Oil prepared from such spoiled copra becomes rancid quickly with bad taste and odour.

Fungi also cause deterioration of copra followed by bacteria P. frequentans, which was found to cause spoilage even at a moisture content of four percent (Nair and Sreemulanathan, 1970). Rao et al (1971) observed the presence of Botryodiplodia theobromae during the blackening of coconut kernel. Paul (1969) and Susamma and Menon (1981) isolated a number of fungi and bacteria from deteriorated copra. The fungi isolated were R. stolonifer, R oryzae, Mucor hiemalis, P. Citrinum, Culvularia Senegalensis, Cochliobolus lunatus, Paecilomyces lilanicus, Aspergillus oryzae and Aspergillus fumigauts. Bacteria causing spoilage were identified as R Subtilis, E. aero genes, Pseudomonas flourescens and Sarcina lutea. The chemical change in the amino acid content due to fungal infection was also investigated (Susamma et al., 1981; Sierra, 1971).

Storage of copra

The general observation in India is that the copra on storage is affected by excessive mould growth when the relative humidity is greater than 85 percent at room temperature or greater than 95 percent at 40°C. In many milling establishments, it is a usual practice to dry copra under the sun for one or two days before bagging and storing. Painting of upper surface of the roof of the storage structure with white reflective paint has been reported to reduce temperature fluctuations within 10°C thus preventing serious condensation effect. The walls also should be shaded from direct sunlight and should be provided with sufficient number of adjustable ventilators (Grimwood and Ashman, 1975).

Sulphuring the copra is effective for storing for longer periods during rainy season. Fumigation of copra with methyl bromide at the rate of 3 kg/100 m3 for 48 hours with a gas proof sheet is recommended when copra is stored in godowns. Fumigation with sulphur dioxide or lindane smoke or pyrethrum and piperonyl butoxide as a fog is also resorted to. Fumigation with a mixture of carbon dioxide and ethylene oxide (99:1) is effective against insect pests of copra. A chemical treatment of dipping fresh kernel in 1000 ppm propionic acid for 60 minutes to preserve it upto 49 days without further drying had been developed (Patil, 1982).

Use of proper packing materials is also an important factor. Plastic lined gunny bags can be used for safe storage of copra even during the rainy season. Multi walled paper bags could keep copra free from insects up to three months and those treated with pyrethrin could be kept up to nine months. Studies at CPCRI, Kasaragod during 1989 have indicated that copra stored in tin containers and polythene bags and fumigated with biogas, neem leaf gas, carbon dioxide and sulphur dioxide are effective in controlling microbial infestation during storage. Copra could be stored for more than

six months by exposing it either to bio-gas for one to three days or to neem leaf gas for 15 days immediately after splitting prior to storage in any air-tight container.

Grades of copra

In all the coconut growing countries, there are recognized grades of copra which form the basis of the trade transactions. Though each producing country has standards for grading, there is no common and uniform international standard for copra. Standard contract terms for milling copra are in force in India since 1949. In Sri Lanka, three grades of copra are defined based on moisture content, oil content and FFA level of pressed oil. In the Philippines, four classes and seven grades of copra are available based on type of moisture content and drying system used. In Western Samoa, grading is done based on the method of drying adopted.

Grade specifications for milling copra as suggested by the Asian and Pacific Coconut Community for adoption by member countries are shown in Table 5.2.

Table 5.2: Standard specifications for copra

SI. No.	Characteristics	Grade 1	Grade 2	Grade 3
1.	Moisture content-per cent by weight maximum	6	6	6
2.	Oil content (on moisture free basis) per cent by weight minimum	70	68	66
3.	Free fatty acid (per cent as lauric per cent by weight maximum)	1	3	6
4.	Aflatoxin content in parts per million maximum	20	20	20
5.	Impurities - per cent weight	0.5	1	2
6.	Immature kernels (Wrinkled) per cent by coconut maximum	Nil	5	10
7.	Mouldy cups (per cent by count) maximum	Nil	4	8

Ensuring the quality of oil

For obtaining a better quality product, it is necessary to crush the copra having a moisture content of less than six per cent. The crushing process should be done in clean surroundings and the oil collected in clean equipments. The crude oil should be filter pressed without much time lag and the storage tanks frequently cleared of sediments and other settled impurities. The oil should be free from moisture, for instance, under the British Standard specification the moisture content must be under 0.25 percent. In the case of refined oil, it is treated and subsequently washed, filtered and/or heated to 110 to 120°C to remove traces of moisture. The latter treatment also effects sterilization. The oil must be stored as far as possible away from light and air. The receptacles may be filled to the maximum possible extent in order to reduce the amount of surface exposed to light and air. Small quantities of oil can be successfully stored in soldered kerosene tins and large quantities in storage tanks.

Quality standards for coconut oil

For coconut oil, there is no uniform international quality standard. In India, the two common grades are unclean and clean oils, the former is chekku and rotary oil and the latter is expeller oil which is usually filtered. The Asian and Pacific Coconut Community have recommended five different grades of coconut oil. Grade I refers to refined and deodorized oil whereas grade II refers to refined oil. Grade III oil is white oil obtained by wet processing. Grade IV and V are referred to as Industrial Oil No. 1 and 2 obtained by the process of mechanical and solvent extraction respectively.

Storage of oil in air-tight brown coloured containers along with sodium meta bisulphate or citric acid or common salt will increase the shelf life of the oil for more than six months. The quality was better in copra produced by the solar dryer, followed by electrical dryer and then by sun drying on cement floor.

Major quality control issues in copra

Aflatoxins in copra

The international recommended procedures for producing good quality copra would be as follows:

(1) The nuts for copra-making should be mature (11-12-month-old).

(2) Drying should be started within 4 hours from splitting to avoid start of microbial action.

(3) To avoid case hardening, the temperature of drying should not exceed 60o C during the first 10 hours and should be about 55oC during the next 14 h.

(4) Copra should be stored with 6% moisture level in well-ventilated areas to prevent mould growth and reduce storage losses.

Virgin Coconut Oil (VCO)

Virgin coconut oil (VCO) is obtained from fresh and mature kernel (12 months old from pollination) of the coconut (Cocos nucifera L.) by mechanical or natural means with or without the application of heat, which does not lead to alteration of the nature of the oil. VCO has not undergone chemical refining, bleaching or deodorizing. It can be consumed in its natural state without the need for further processing. Virgin coconut oil consists mainly of medium chain tryglycerides, which are resistant to peroxidation. The fatty acids in virgin coconut oil are distinct from animal fats which contain mainly of long chain saturated fatty acids. Virgin coconut oil is colorless, free of sediment with natural fresh coconut scent. It is free from rancid odor or taste.

Table 5.3: Quality parameters of VCO

Sl.No.	Parameters	Limit
1	Moisture (%)	Max 0.1
2	Matters Volatile at 1200 C (%)	Max 0.2
3	Free Fatty Acid (%)	Max 0.2

4	Peroxide Value meq/kg	Max 3
5	Relative density	0.915 – 0.920
6	Refractive index at 400 C	1.4480 – 1.4492
7	Insoluble impurities per cent by mass	Max 0.05
8	Saponification Value	250 – 260 min
9	Iodine Value	4.1 -11
10	Unsaponifiable matter % by mass,	max 0.2 - 0.5
11	Specific gravity at 30 deg./30 deg. C	0.915 – 0.920
12	Polenske Value, min	13
13	Total Plate Count	< 0.5
14	Color	Water clear
15	Odor and Taste	Natural fresh coconut scent, free of sediment, free from rancid odor and taste

Food safety standards for VCO

VCO is considered a functional food and is increasingly consumed and/or processed into nutraceutical products. It is not only used as a food ingredient but also as a food supplement that people take for its health benefits. As such, it has to be carefully processed with food safety considerations at the forefront. While it is not generally required for a VCO plant to be HACCP compliant when it is just starting its operation, strict adherence to the prerequisite programmes of HACCP by processors is strongly recommended. Table 5.4 illustrates the HACCP plan of coconut flour and VCO.

Table 5.4: HACCP Plan – Coconut Flour & Virgin coconut oil

CCP#	CCP1 Coconut flour	CCP1 Virgin coconut oil
Step	Metal Detection	Final Polishing (SSfilter,cloth)
Risk	Physical	Physical
Hazard	Metal	Metal fragments
ControlMeasure	• Sensitivity and accuracy test • Calibration, Equipment Design • Preventive Maintenance Program • Validation of Test Piece	• Preventive Maintenance Program • Filter cloth cleaning, re-use and replacement procedure • Use of screen mesh #5:4mm and filter cloth 5µ
CriticalLimits	Ferrous:2.0mm Stainless steel:2.5mm Non-Ferrous:2.5mm	Absence of metal and injurious fragments in finished product VCO
Monitoring	Every 30 minutes checking of sensitivity using the test piece (Ferrous,Stainless Steel and Non-Ferrous) placed individually inside the finished product of a 100lbs. bag	Monitoring of equipment every 24th hour.

Corrective Action	• Alarm of metal detector is triggered whenever a suspected bag with metal contamination is detected. Belt conveyor will automatically stop. • All bags suspected with metal contamination shall be segregated and place into the Category II area and subject for re-picking then re-process. Any metal found is subject for corrective and preventive action report. • In the event of metal detector failure, hold the product produced since the last good check and rerun held product through a properly operating and validated metal detector. • Re-training of personnel	• Turn-off Final Polisher for dismantling • Inspection and replacement of damaged screen and/or filter cloth • Finished product produced since last good check will be subjected for re-evaluation and re-filter
Verification	• Monitoring of test piece (Ferrous, Stainless Steel, Non-Ferrous) every 30 minutes. • Probability of Detection (POD) Monitoring once a week • Review of records	Visual Inspection of finished product
Validation of control measures; CLs	• Annual validation of test piece, and in event there is a change in sensitivity setting • Calibration of metal detector twice a year	Annual validation of equipment
Documentation	• CCP3:Metal Detection Checklist (PCPI-CH-WH02Rev.5) • Corrective Action • Calibration Certificate • Validation Records • Training Records	• Cleaning, Re-useand Replacement Procedure of Filter Cloth(PCPI-SOP-VCO-CRRRev.1)
Responsible	• Coconut Flour Production Manager • Engineering • QA	• QA • VCO ProductionManager • Polisher Operator

GMPs in VCO production cover the adherence to a specific set of guidelines for each of the following stages:

- pre-processing stage – all the steps before the coconuts are opened for conversion into VCO: harvesting, collection, husking, transport, storage;
- processing stage – the actual steps in the processing of fresh coconut into VCO, from opening the nuts to recovering the VCO, varying according to the technology;
- post-processing stage – additional steps to further improve the quality of VCO: fine filtration, oil drying (if required) and ageing (if required)
- Packaging and storage of the product.

GMP for VCO production

1. GMPs for selection of nuts

On-farm selection of coconuts for VCO processing consists of segregating the good mature nuts from the over- mature nuts with signs of germination or growth. For VCO production, only sound, fully mature nuts (12–13 months old) should be selected as these have the highest oil content and the lowest moisture content. Nuts with cracks, or a damaged soft eye or germination growth exceeding 1 cm must be discarded. Over-mature nuts (above 13 months old), especially those which have already germinated, impart an off-flavour and oily taste to coconut products so they should be discarded.

2. GMPs for dehusking of coconuts

- The husking should be done early in the morning or in a shady area. Hence, the husked nuts are not exposed to direct sunlight. Exposure of husked nuts to direct sunlight for more than an hour will cause the shell to crack.
- If the coconuts are not to be processed within two days from the time of husking, keep the eye of the nut adequately covered by leaving a portion of the husk attached to it during husking.

3. GMPs for the transport of husked nuts to the VCO processing plant

Cover the coconuts if they are in an open vehicle and the transport time is more than an hour. Proper care must be taken during loading and unloading of the nuts to avoid the broken. Ideally, dehusked coconuts should be processed within seven days from the time of harvest. Accordingly, VCO processing facilities should be set up within the coconut producing areas to ensure the freshness of the raw material.

4. GMPs for the inspection of nuts at the VCO plant

The nuts are inspected yet again on delivery to the plant. Dehusked nuts with a cracked shell, or a damaged soft eye should be rejected.

5. GMPs for the storage of nuts

- Husked nuts should be kept in clean storage areas with cement floors and good ventilation
- Storage bins should be designed and partitioned so that the principle of first in, first out can be easily implemented.
- The husked nuts should not be placed directly on a cement floor but on an elevated platform (pallet) with slats which is at least six inches above the floor. In this way, coconut water can flow away from the pile if coconut shell breakages occur.
- The stockpile of husked coconuts should be inspected daily to remove nuts with cracked shells and soft eyes.
- The height of a storage pile of coconuts should not exceed 1.8 m.
- In addition, never store coconuts in plastic sacks. Since there is no air circulating inside the sacks, moisture emanating from the fresh nuts is trapped inside and will cause deterioration of the nuts. The situation is aggravated if there are nuts with a cracked shell or a deteriorating eye in the sack.

6. GMPs for the Processing Stage

6.1. GMPs for handling coconut water

GMPs on the proper handling of coconut water are important because it spoils and ferments very fast once the nut is split.

- Do not split the coconuts at too high a level above the coconut water receptacle because there will be a tendency for the water to splash on the floor.
- If the coconut water is not to be used in VCO processing or is not be further processed, remove it at intervals from the splitting area and dispose of it in dedicated septic tanks to prevent the generation of a foul odour in the process area. Do not dispose of large quantities of coconut water directly into drains or a sewage system, or into a creek, a river or the sea without proper treatment.

Immediately wash the floor with water if coconut water gets spilled on it. Spilled coconut water on the floor if not immediately cleaned will attract flies and become a source of contamination. It will also destroy the cement surface of the floor (if there are no tiles) since fermented coconut water becomes very acidic.

6.2. Selection of coconut kernels for processing

Quality control on the fresh coconut kernel should be done after splitting the nuts to ensure that only fresh, unspoiled coconut flesh is further processed. The kernel should be firm in texture and white/opaque in colour. Coconut kernel with a soft texture, slimy surface or discolouration should

be segregated and discarded. Likewise, kernel from nuts with big haustorium or germination growth is soft and thin and has a rancid smell. Hence, it must be discarded as it will destroy the quality of the whole batch.

As a general rule, coconuts for food products should be processed within four hours from the time the shell is broken or the nut is split.

6.3. GMPs for removal of the coconut kernel and particle size reduction

All parts of the processing equipment that come into contact with the coconut kernel should preferably be made of food-grade stainless steel.

6.3.1. Guidelines for manual grating of coconuts

- Before starting to grate, wash the grater blade thoroughly with soap and water. Use hot water for the last rinse.
- Manual grating should not be done while one is sitting on the ground/floor, but if there is no alternative, sit a clean cement floor.
- Use a clean container (stainless steel or white plastic basin) as a receptacle for the grated coconut kernel.
- Do not place any split coconuts on the ground.

6.3.2. Guidelines for motorised grating

- Ensure that the blades and housing of the grater are thoroughly cleaned with soap and water before starting the operation. Make certain that no soap residue is left on the surface by thoroughly rinsing with water. Use hot/boiling water for the last rinse to sanitise.
- Avoid touching the grated kernel with bare hands. Use a stainless steel ladle when removing the grated flesh that adheres to the surface of the grater housing.
- Make certain that only highly skilled operators do motorised grating. The rotating metal blades of the grater may cause injury if the grater is handled by unskilled or untrained workers.
- Clean the grater blades and housing immediately after each use.

6.4. GMPs for fresh-dry process

6.4.1. GMPs for drying of freshly comminuted kernel

- Drying of the freshly comminuted kernel is the most critical step in the fresh-dry process.
- Delay in drying or the use of improper drying techniques produces second grade VCO.

6.4.2. GMP guidelines for drying

- Dry the coconut kernel within four hours of splitting the nut. Beyond four hours, the nut will yield yellow or pink oil due to microbial attack. The risk is much higher in kernels of small particle size (as in this case) because more surface area of the kernel is exposed.

- Dry the comminuted kernel at the appropriate temperature (70–75°C) to prevent it from being burned or scorched. High temperature and improper drying techniques result in unacceptable pale yellow coconut oil with a burnt odour. If the drying temperature is too low, bacterial contamination may occur which also results in unacceptable yellow-coloured oil.
- Do not overload the dryer. Just load the amount of grated/shredded/milled coconut kernel according to the specified processing capacity. Overloading the dryer can cause deterioration of the kernel that is not reached by heat and may also result in yellow-coloured oil.
- Dry the comminuted kernel to the right moisture content as specified in the type of VCO fresh- dry processing technology that is used (e.g. 10–12% for the low pressure method, 3–4% for the high pressure expeller and fresh-dry centrifuge process).

6.5. GMPs for fresh-wet processes

6.5.1. GMPs for coconut milk extraction

Coconut milk is categorized as a low acid food. It contains proteins and other nutrients in which micro-organisms from the air and other sources can thrive. In addition, coconut milk has a high moisture content which allows microorganisms to multiply very fast. Correct handling of coconut milk is therefore critical in the fresh-wet VCO process, since there is a very high risk of spoilage if is not processed under strict conditions.

- All containers, receptacles and utensils used during the extraction of coconut milk should be made of food-grade stainless steel. If stainless steel is not available, food-grade plastic white containers should be used.
- Ensure that all materials, utensils and equipment are thoroughly cleaned and rinsed with hot water. They should be free from any soapy residue.
- Water used for dilution for a second milk extraction should be of high quality, free from microbial contamination and of low mineral content. Coconut water can also be used for dilution purposes but specific handling procedures need to be followed, especially during hot weather (i.e. filtration and immediate storage in a refrigerator or ice box while waiting for the grating and first milk extraction to be finished). Otherwise, the coconut water will start to ferment, which will make it unsuitable for dilution purposes.
- Thoroughly wash your hands with soap and water before doing any preparation work. In addition to the above general guidelines, the following should be observed if coconut milk is extracted manually.
    a. Remove rings from fingers when directly handling and mashing grated coconut kernel for milk extraction.
    b. Do coconut milk extraction on top of a table. Any plastic containers used as receptacles should be food-grade and white.
    c. Ensure that the cloth is clean and sanitised.

In addition to the above general guidelines, the practices listed below need to be observed if the coconut milk is to be extracted using a manually operated and motorised hydraulic press.

- All parts of equipment which come into contact with coconut kernel and coconut milk should be made of stainless steel.
- Equipment should be rinsed with hot water before use and cleaned every four hours during operation in order to prevent contamination. All equipment is to be thoroughly cleaned at the end of the day's shift.
- Never leave the equipment with adhering grated coconut kernel and film of coconut milk on the surface after use because it will develop a bad odour and attract flies and other insects.
- Bags for holding the grated coconut kernel should be made either of white plastic nets with fine mesh or sanitized cheesecloth or canvas cloth.
- The person who does the bagging should observe proper personal hygiene (e.g. not report for work if ill, remove rings from the fingers, wear gloves, etc.) before starting work.

6.6. GMPs for recovery of VCO using the modified natural fermentation process

Settling and fermentation are the critical steps in this process, and they require proper control of operating conditions and observance of strict sanitary measures. There are cases in which no oil separates, even after 24 hours settling. There are also cases when the coconut milk mixture that is left to settle for 12–16 hours generates big bubbles and no oil separates.

To ensure that good quality VCO is produced, the measures below should be taken.

- Place the diluted coconut milk in food-grade transparent white plastic containers and allow it to settle for 12–16 hours, preferably at a temperature of 35°–40°C. Fermentation does occur at temperatures below 35°C but the oil recovery for premium grade VCO is lower.
- Fermentation continues up to 36 hours if allowed. However, fermentation time is set at 16 hours to get premium grade VCO. The longer the fermentation time, the more intense the sour smell in the coconut oil and the higher the risk of free fatty acids increasing to levels above those permitted in the VCO standard.
- Relative humidity within the area should be maintained below 75%.
- Loosely cover the container of coconut milk to allow the release of carbon dioxide which is generated during fermentation.
- Strict sanitary measures have to be observed at all times.
- Use a stainless steel strainer and soup ladle for taking the VCO out of the fermenting container.
- Ensure that all containers and utensils used in recovering and holding the VCO are clean and thoroughly dried.
- Dispose of the fermented skim milk (watery phase) and gummy portions properly in a designated septic tank. Do not put it directly into the sewage system.
- Fermentation of the curd can be allowed to continue for another 24 hours after recovering the

premium grade VCO. The curd still contains a lot of oil, especially the top layer, and can be used to recover second grade VCO.

- The suspended particles including coagulated protein and fermented curd are floating on the surface of the oil. They can be removed by a simple filtration method using fine strainer, cheese cloth or course filter paper. This method does not leave any unsightly residue at the bottom of the bottle after it is packed and left on the shelf for some time.
- Always ensure that the container to be used to hold the oil or any filtering medium is dry, clean and free from any dirt or extraneous matter.

7. Good manufacturing practices for the post-processing stage

7.1. GMPs for oil drying

- Never heat the oil directly in a pot or pan as this will cause it to turn yellow.
- In using an improvised double boiler for oil drying, ensure that the bottom of the mixing bowl holding the oil is touching the water in the pot.
- Ensure that all process containers and utensils are thoroughly cleaned and dried.
- Ensure that the cheese cloth used to cover the VCO container is sanitised and dry.
- When transferring VCO to packaging containers after ageing, always leave behind about 2 cm of oil at the bottom. Any residual moisture in the oil settles in this bottom layer after aging.

8. GMPs for packaging and storage of VCO

- In selecting plastic bottles for packaging, always ensure that they are food-grade and do not impart any flavour to the oil.
- Always ensure that the container (glass or plastic) is thoroughly clean and dry before filling it with VCO.
- If packaging VCO in glass bottles with metal caps that automatically seal with a vacuum, fill the bottle up to the top. Moisture in trapped air in the empty space may condense and cause the oil to become rancid.
- Cover the container immediately after filling.
- Store packaged VCO in an enclosed area with screened windows, protected from rain and away from direct sunlight and materials with a strong odour.

Sanitation Standard Operating Procedures (SSOPs)

Sanitation standard operating procedures (SSOP) are activities related to the sanitary handling of raw materials, food products, work areas and equipment. They ascertain that conditions prescribed by GMPs are met by plant facilities and operations. They ensure the effectiveness of maintenance, corrective actions and record keeping activities.

Cleanliness and sanitation of plant and premises include both maintenance of clean and well sanitized surfaces of all equipment coming into contact with food, good housekeeping in and about

the plant, and correct disposal of waste.

SSOPs for VCO processing cover the following aspects:

a. sanitation in the processing area

b. sanitation in the processing equipment

c. personal hygiene

a. Sanitation in the processing area

Cleaning and disinfecting processing areas should not be neglected: they can substantially reduce the risk of VCO not meeting consumer and government standards. Translated into business terms, strict adherence to sanitary procedures will mean zero or fewer rejections and complaints and zero involvement in outbreaks of food poisoning.

Guidelines for cleanliness and sanitation

- Frequent and continuous cleaning must be done at the various process section areas (e.g. regular removal of waste and by-products) as well as cleaning at the end of every eight hour period and/or at the end of every production shift. The purpose of continuous cleaning is to keep waste from accumulating during the operating day, which not only improves sanitation, but also reduces the time needed for end-of-shift cleaning.
- Every weekend (or once a week), every process area should be scrubbed with soap and water and rinsed. An anti-bacterial agent must be applied.
- Ceilings and roof spaces should be regularly monitored and appropriate measures taken to keep them free of insects, geckos and rodents.
- The grating and milk extraction areas or the shelling, washing and kernel grinding area (in the case of the fresh-dry VCO process) should be regularly cleaned every eight hours to prevent microorganisms from building up. The cleaning can be done by washing off all coconut flesh using a high pressure hose. It should be noted that immediate flushing with water is required whenever coconut water is spilled in the floor.
- An exhaust fan should be installed in the fermentation room of the VCO facility using the modified natural fermentation method. The exhaust fan should be run for at least half an hour at the end of every fermentation cycle to remove stale air, laden with carbon dioxide, from the room. Likewise, the fermentation room should be airy, allowing fresh air to circulate.
- Packaging areas should be equipped with a white formica-topped table and should be cleaned after every use. Any spillage of oil in the floor must be immediately cleaned with soap and water to prevent accidents.

Guidelines for handling the by-products

- Coconut shells should be regularly removed from the grating area.
- If coconut water is not to be further processed, regularly dispose of it in an assigned disposal

area or septic tank after proper treatment to prevent the generation of a foul odour in the process area. It should be noted that coconut water starts to ferment within four hours of splitting the nuts.

- Flush the area with water if coconut water gets spilled on the floor. Spilled coconut water on the floor, if not immediately cleaned, attracts flies and becomes a source of contamination. It will also destroy the surface of a cement floor since fermented coconut water is very acidic.
- In the case of a plant producing VCO from coconut milk, the coconut milk residue generated after milk extraction should be regularly transferred to the drying area or the area where it will be further processed. Please note that wet coconut milk residue, if left unattended for more than four hours, will deteriorate and cause a foul odour and microbial contamination.

b. Sanitation in processing equipment

Food-grade stainless steel is the recommended material of construction for all parts of VCO processing equipment that come in contact with coconut kernel or milk. The following sanitation guidelines are listed that should be followed for equipment.

- All equipment where fresh coconut kernel is being handled /processed should be cleaned after every four hours of use. It must all be cleaned at the end of each production cycle. Cleaned equipment should be free of grease and adhering product particles, detergent residue, brush bristles, etc.
- Use hot or boiling water for the final rinse of the equipment.
- Special attention should be given to the internal parts of coconut milk presses to ensure that no coconut kernel particles are left adhering to the surface of the equipment filter or perforated cage or loading cylinders at the end of production day. They should be flushed out with pressurized water.
- The blades of coconut graters, including the housing, must be thoroughly cleaned with water every four hours of operation and with soap and water at the end of the production day. Use hot or boiling water for the final rinse to prevent bacterial contamination.
- The intake, internal and discharge points of the grinder or shredder need to be cleaned with cold water and rinsed with hot water every four hours. They should be thoroughly cleaned and free from any adhering particles of coconut kernel at the end of production day.
- In the case of the VCO plants using the low pressure oil extraction method and the high pressure expeller process, dryers should be cleaned every eight hours. This includes complete removal of coconut particles, specifically the yellow/scorched particles adhering to the dryer surface which holds the coconut kernel (e.g. tray for tray type dryer and apron for conveyor type dryer). It should be noted that dried coconut particles should not be left in the area for more than 24 hours.
- All tools and equipment accessories should also be thoroughly cleaned before and after use.

Personal hygiene

A major source of contamination is through the people who are actually involved in the processing of VCO. Hence, in maintaining sanitation, personal hygiene has to be given equal consideration to other HACCP aspects, such as building layout and processing equipment. A washing area should be placed near the entry point so that workers can wash their hands with soap and water, prior to dipping them in an antiseptic solution. Only healthy personnel should be working in the processing areas.

Desiccated Coconut (DC)

The packaged desiccated coconut should be stored in well ventilated warehouses and not shipped until microbiological tests are negative for salmonella. Exported DC is sometimes found to be rancid due to enzymatic hydrolysis of coconut oil. This result in a soapy flavour, due to the release of free fatty acids, principally lauric acid, at a level of around 0.25% .The problem can be minimized by ensuring that only good coconuts are preserved after efficient blanching of the kernel to reduce any microbial contamination. Tables 5.5 give the current HACCP specifications for desiccated coconut.

Table 5.5: HACCP Plan for Desiccated Coconut

	CCP1	CCP2	CCP3
Step	Chemical Treatment (Dip Tank @ Line 1 & 3) Sulfite SpraySystem @ Line 2	Blanching	Metal Detection
Risk	Chemical	Biological	Physical
Hazard	Overdosing of chemical (Sodium Metabisulfite Solution), Allergen	Pathogens (i.e. Salmonella, E.coli)	Metal
Control Measure	Proper preparation and dosing Allergen Control Program	• Application of heat, correct thermal process temperature and time • Validation of retention time & temperature • SSOP# 2 Condition & cleanliness of Food Contact Surfaces.	• Sensitivity and accuracy test • Calibration, Equipment Design • Preventive Maintenance Program • Validation of Test Piece
Critical Limits	Dip Tank (soaking liquor) 50 ppm, 2.2ml (granulated), 1.4ml (special cut), 100 ppm, 4.0ml (granulated), 3.4ml (special cut) Sulfite Spray 50 ppm, Flow Rate = 164 ml/ min @ 50 psi flow meter set point 100ppm, Flow Rate = 298 ml/ min@ 90 psi flow meter set point	190°F @ 9 minutes	Ferrous: 2.0mm Stainless steel: 2.5mm No n-Ferrous: 2.5mm

Monitoring	Dip Tank Testing of soaking liquor concentration every 30 minutes Sulfite Spray System Checking of Flow Rate and Flow Meter set point once per shift	• Temperature of the digital recorder shall be checked from time to time and shall be recorded hourly. • Retention time shall be checked once a shift (a piece of white meat shall put at the start of blanching and start timing using a calibrated stop watch until it reaches the blancher discharge)	•Every30minutes checking of sensitivity using the test piece (Ferrous, Stainless Steel and Non-Ferrous) placed individually inside the finished product of a 100lbs bag
Corrective Action	Dip tank : •If the concentration of soaking liquor is low, add sodium metabisulfite solution, if high add water to the chemical tank and proceed to retesting of water strength. Sulfite Spray: •Re-training of personnel For Allergen Control: •if found to have traces of allergen after cleaning, re-cleaning shall be do ne.	•In event of equipment failure (e.g. steam pressure drop and temperature lowering) the alarm and screw conveyor auto-stop interlock mechanism is trigerred ensuring that no under-blanched milled meat exit the blanching chamber and fed into the dryer. •Re-training of personnel	•Alarm of metal detector is triggered whenever a suspected bag with metal contamination is detected. Belt conveyor will automatically stop. •Any metal found is subject for corrective and preventive action report •Re-training of personnel
Verification	•Line monitoring of residual SO2 of the finished product– every two hours. •Sulfite testing done on equipment after cleaning (i.e. conveyors, chemical tank, grinder) using •Review of records	•Microbiological analysis of sample before and after blanching •Monthly checking of alarm system •Equipment swabbing •Equipment cleaning and sanitation •Review of records	•Monitoring of test piece •Profitability of Detection (POD) Monitoring once in a week •Review of records
Validation of control measures; CLs	•Annual validation of critical limits. •Calibration of measuring device - twice a year	•Annual validation of temperature and retention time •Calibration of Equipment twice a year	•Annual validation of test piece •Calibration of metal detector twice a year

Documentation	•CCP 1: Chemical Treatment Tank •Residual SO2 Analysis (PM X-QCD) •Calibration Certificate •Validation Records •Training Records	•CCP 2: •Checklist During Shutdown & Cleaning of Blancher (PCPI-CH-WT09 Rev.5) •Alarm system records •Calibration Certificate •Microbiological Analysis Records •Validation Records •Training Records	•CCP 3: Metal Detection •P OD Records •Calibration Certificate •Validation Records •Training Records
Responsible	•WGB Supervisors •Engineering •QA	•WGB Supervisors •Engineering •QA	•WGB Supervisors •Engineering •QA

HACCP system has been introduced only for desiccated coconut industry. Virgin Coconut Oil (VCO) and White Edible Copra (WEC) are two products which enjoy good international market. The constraints found in WEC industry towards HACCP adoption is mostly related to problems associated with internal environment. Further the top most severe constraints identified are lack of knowledge on HACCP, wrong attitudes towards HACCP, no effective team work, and lack of infrastructure.

HACCP and GMP certified companies

Cocotana Coconut Products (CCP): This is the leading manufacturer and exporter in Sri Lanka, which is an ISO 22000, HACCP and GMP certified company. It is a global supplier of certified, organic, natural and conventional coconut products and possesses a wide range of product line that comprise from organic VCO, DC (fine and medium grades), coconut chips/flakes, creamed coconut, coconut milk, coconut cream, coconut water, defatted coconut and coconut flour.

T.M.Duche & Sons Ltd: This is one of Europe's largest traders in desiccated coconut, exclusively representing Primex Coco Products and Coco Davao, manufacturers of some of the highest quality coconut products in the world.

5.9. Food Quality and Safety Standards related to Cocoa

Production of cocoa and chocolate products free from contamination of pathogens, foreign bodies, and residues and contaminants is of the utmost importance in promoting sustainable consumption. While there are of course many other aspects to a sustainable cocoa economy and to sustainable consumption specifically, perhaps the minimum "entry-level" criteria which must be followed are the principles necessary to make safe products. International Confectionery Association (ICA) has documented the specific Good Manufacturing Practices (GMP) for the Cocoa, Chocolate and Confectionery industry, which are essential to ensure sustainable consumption of cocoa containing products.

Within the last 20 years, chocolate products have been the cause of many salmonellosis outbreaks involving mainly children. The main reason has been the very low levels of Salmonella found in such contaminated chocolate products. Additionally, chocolate may contain other spoilage organisms such as yeasts and molds, Staphylococcus aureus and other coliforms. It is therefore necessary to take preventive measures during processing to avoid re-contamination of the product after the roasting step which represents the only barrier for Salmonella and other spoilage microorganisms. HACCP systems are therefore designed to prevent re-contamination. The control of hazards in chocolate processing is essential to avoid illness, injury or in the most severe cases, death to the consumer.

Hazards associated with chocolate processing

The major hazards identified in the processing of cocoa beans and chocolate manufacture is physical, microbiological and chemical in nature.

Physical hazards: Sources of physical hazards during chocolate production and processing usually are from incoming raw materials, processing equipment and failures in pre-requisite programmes.

Chemical hazards: Two main sources viz; intrinsic contamination of raw materials and contamination that may occur during the process. At high doses, the exposure to chemical contaminants can cause toxicity to the consumer, for example acute poisoning from the ingestion of high levels of lead.

Microbiological hazards: Microbial hazards in cocoa processing and chocolate manufacture are mainly present during the incoming of raw materials and improper handling. Hence, chocolate should be tested for Staphylococcus aureus, coliforms, and Salmonella.

Table 5.6 shows a model for the determination of critical control points (CCPs) for production of milk chocolate manufacture based on the HACCP decision tree (Codex Alimentarius Commission, 1999). Four critical points were identified for the manufacture of milk chocolate The ISO 22000 Analysis worksheet reduced the CCPs for chocolate manufacture due to the elimination of the pre-requisite programmes (PrPs). Monitoring systems were established for the CCPs identified and these included preventive measures, critical limits, corrective actions, assignment of responsibilities and verification procedures.

Table 5.6: Identification of Critical Control Points (CCP) based on HACCP decision tree (Codex Alimentarius, 1999) for milk chocolate production

Processing Step	Hazard	Do preventive control measures exist?	Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?	Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increases to unacceptable levels?	Will a subsequent step eliminate identified hazards or reduce likely occurrence to an acceptable levels?	Is the processing step a CCP?
Raw materials reception	Microbio-logical	Yes	Yes	-	-	CCP1
Mixing	Physical	Yes	Yes	-	-	CCP2
Refining	Physical	Yes	No	No	-	Not CCP
Conching	Physical	Yes	No	No	-	Not CCP
Casting and moulding	Microbio-logical	Yes	Yes	-	-	CCP3
Wrapping and labelling	Microbio-logical	Yes	Yes	-	-	CCP4
Storage	Physical	Yes	Yes	No	-	Not CCP

Precautions to be taken

Chocolate and Cocoa processing: Salmonella contamination and other enteric infections can be a problem with chocolate products. Sanitation is a major problem, especially since many chocolate products are finished by hand-dipping; employee sanitation practices are, therefore, very important to prevent product contamination.

Storage of cocoa beans, nuts and coconuts should be checked for insects, rodents, and mycotoxins. Insect infestation in processing machinery can be a problem if equipment is not cleaned regularly.

A model HACCP

A Venezuelan cocoa processing facility has built up a HACCP system upon a solid foundation of prerequisite programs such as Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP). Good Agriculture Practices (GAP) audit to cocoa nibs suppliers (Motarjemi and Lelieveld, 2013). To develop the HACCP plan, the five preliminary tasks and the seven HACCP principles were accomplished according to Codex Alimentarius procedures. Three Critical Control Points (CCP) were identified using a decision tree:

- Winnowing (control of ochratoxin A),

- Roasting (Salmonella control)
- Metallic particles detection.

For each CCP, Critical limits were established, the Monitoring procedures, Corrective actions, procedures for verification and documentation concerning all procedures were established.

5.10. Food Quality and Safety Standards related to Cashewnut

Cashew (Anacardium occidentale L.) is one of the important tropical crops. India processed about 1.18 million tonnes of raw cashew seeds through 3650 cashew processing industries scattered in many states of country provided employment to over 0.5 million people.

The general processing steps involved in cashew processing are drying of freshly harvested raw seed for storage, Soaking of seed, Steam cooking or roasting, Shelling, Separation, Kernel drying, Peeling and Packaging. Cashew industry in India is concentrated in Kollam district of Kerala, Dakshina Kannada district of Karnataka, Panruti area of Tamil Nadu and to some extent in Goa and Maharashtra.

Quality of cashewnuts harvested by different methods

The cashew nut consists of kernel, shell and testa. It contains on an average 20 to 22% kernel (edible portion), 2-5% testa and 65-75% shell (outer covering). The cashew nut shell contains 25-30% dark reddish brown viscous phenolic liquid known as Cashew Nut Shell Liquid and abbreviated as CNSL

About 70 per cent of the farms follow thrashing by stick and collection method. Climbing on the tree and thrashing and shaking the tree to harvest the nuts amounts to 10% and 5% respectively. Certainly, this will increase the percentage of immature nuts supplied to the industries. It also results in dropping of young flowers and ultimately reduces the production and is a usual practice to harvest nuts just before they mature because of theft incidences. This is not a good practice because it results in poor quality of the kernels.

Best quality nuts are obtained where freshly fallen fruits are collected, but only 15 per cent of farms follow the collection of nuts after natural drop. The apples are removed and the nuts are sun-dried for 2-3 days to reduce moisture from 25 per cent to below 9 per cent. It is very essential to dry the nuts after harvest to prevent spoilage during subsequent storage. By proper drying, the kernels retain their quality, in particular, the flavour.

Quality check for cashew nuts

The mature nuts will sink in water while the immature / unfilled ones will float. This test could be used to find out whether the nuts are mature or not.

Safe guidelines for harvesting of cashewnuts

- Ripe apples for fresh use should be picked almost daily. Area under the tree should be weed

free and swept clean to facilitate nut collection

- If cashew apples are used for processing, it is better to harvest them from the tree without damaging the apples.
- Nuts should be gathered at weekly intervals during the cropping season and care must be taken to avoid pest attack.

Overview of cashew nut processing

Grades of cashew

White wholes	
W180 (super large)	Between 120 and 180 kernels per lb (266 to 395 per kg)
W210 (large)	Between 200 and 210 kernels per lb (395 to 465 per kg)
W240	Between 230 and 240 kernels per lb (485 to 530 per kg)
W280	Between 270 and 280 kernels per lb (575 to 620 per kg)
W320	Between 300 and 320 kernels per lb (660 to 706 per kg)
W450	Between 400 and 450 kernels per lb (880 to 990 per kg)
White pieces	
Butts	A kernel broken cleanly across the section of the nut
Splits	A kernel which has broken down the natural line of cleavage to form a cotyledon
Pieces	A kernel which has broken across the section but does not qualify for a butt and is above a specific size
Small pieces	As above but smaller
Baby bits	Very small pieces of kernel which are white in colour

Key area of safety for cashew nuts

HACCP analysis of dry roasted cashew nuts

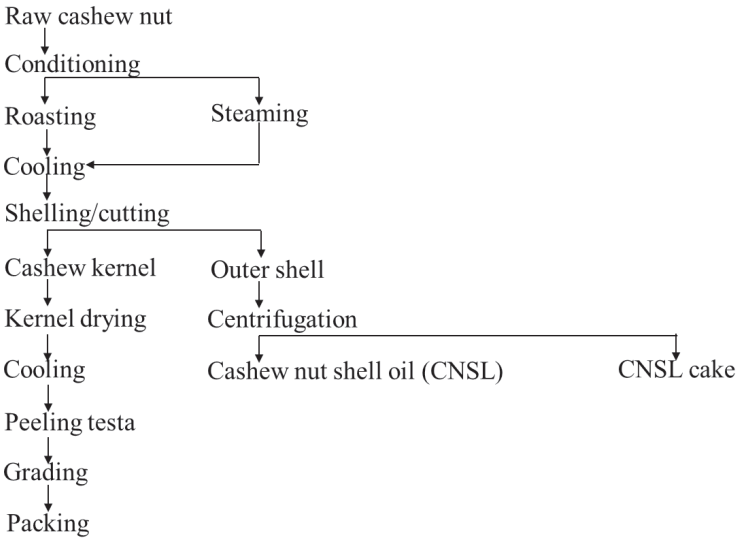


Fig 5.1: Overview of Cashew nut Processing

The Table 5.7 illustrates contaminations may be present in the processed cashew nuts.

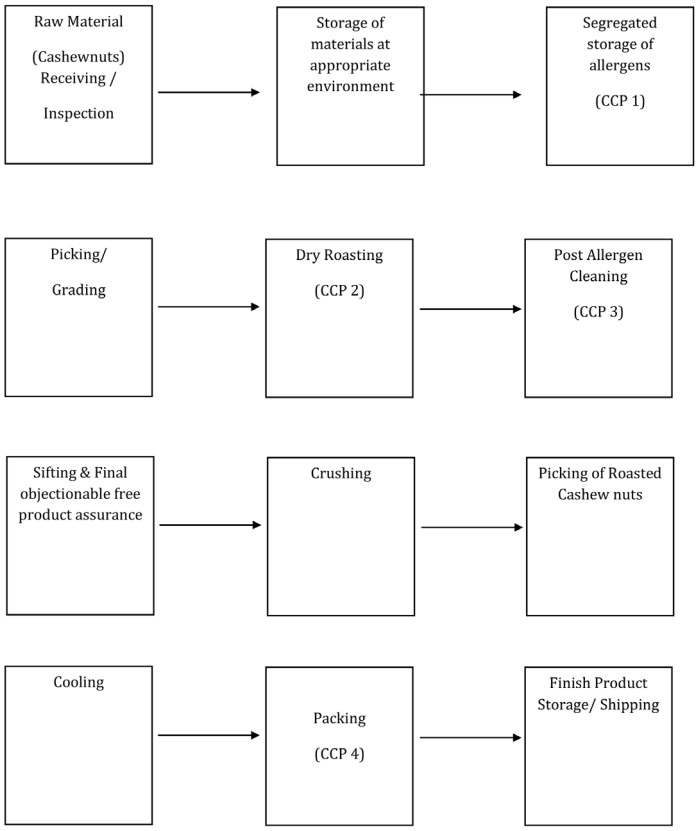


Table 5.7: Hazard Identification for dry roasted cashewnut processing

S.No.	Procedures/Steps Involved	Biological Hazard	Chemical hazards	Physical Hazards
1.	Receiving (Cashew Nuts)	Toxins, Yeast, Mold, Coliforms	Heavy metals, Aflatoxin, cross contamination by preservatives	Broken shells, Foreign matter
2.	Segregated storage of allergens (cashew nuts)	Growth of pathogens/ microorganisms	Allergen contamination	Unlikely
3.	Picking	Pathogenic microbes	Not common	Foreign matter
4.	Dry Roasting	Micro-organisms	Not common	Foreign matter
5.	Cooling	Pathogenic microbes	Not common	Foreign matters like iron, wire pieces, broken hair and etc.,
6.	Picking of roasted cashew nuts	Not common	Not common	Foreign matter like dust and impurities
7.	Crushing	Development of micro-organisms	Not common	External substances
8.	Shifting and Final objectionable free product assurance	Pathogenic microbes	Not common	Foreign matter

9.	Post allergen cleaning and validation	Micro-organisms/ pest damage	Cross contamination	Foreign matter
10.	Packing	Pathogenic microbes	Aflatoxin	Foreign matter
11.	Finished product storage/ Shipping	Development of micro-organisms and contaminant creation mostly because of high temperature	Not common	Foreign matter

Table 5.8: HACCP control chart for dry roasted cashew nut processing plant

CCP #	Raw material/ process steps CCP Description	Hazard Type	Critical Limit	Monitoring			Corrective Actions		Verifications			Documents/ Records
				Procedure	Frequency	Responsibility	Procedure	Responsibility	Procedure	Frequency	Responsibility	
1.	Identification and segregated storage for allergen materials	C	It should be clearly marked as allergen and not to be mixed with other non-allergen products in storage	Visual	Continuous	QC Inspector/ Store In-charge/ Area In-charge	Assure compliance	QCO/ QA manager, production manager	Review records/ visual by visiting the site	Monthly / Occasionally	QCO/QA manager	Training record for monitoring staff, Allergen Audit Report.
2.	Roasting of materials (Cashew nuts)	B	Temperature > 100°C	Temperature gauge reading	Each time during roasting	Line Staff/ QC staff	Inform QCO/ QA manager and	Production manager	Review records/ visual	Monthly / Occasionally	QCO/QA and production manager	Training records for monitoring staff,

							production manager, In case non - compliance gauge to be read and calibrated		by visiting the site			QC inspection report, In process records, CCP deviation records, calibration
3.	Cleaning after running of allergens	C	There should be no residues from the previous run	Manual cleaning / washing where applicable	Each time before switch over	Line staff	Inform QCO/QA, manager, production manager, In case of non-compliance don't allow to switch over and	Production manager	Review records/ visual by visiting the site	Monthly / Occasionally	QCO/QA and production manager	Training records for monitoring staff, QC inspection report, In process records, allergen product management record, QP for
							assure re-compliance					allergen cleaning validation, hold records, CCP deviation records
4.	Final packaging and foreign materials free product assurance	P	Finished product must be free from foreign particles any visual foreign materials	Manual/ visual	Each time before packing	Line production staff/ QC inspector	Inform QCO/QA, manager, production manager, In case of non-compliance don't pack materials without proper compliance	QCO/QA, manager, production manager	Review records/ visual by visiting the site	Monthly / Occasionally	QCO/QA and production manager	Training records for monitoring staff, QC inspection report, In process records, CCP deviation records, calibration
QCO – quality control officer, QA/C – Quality analyst/controller, CCP – critical control limit												

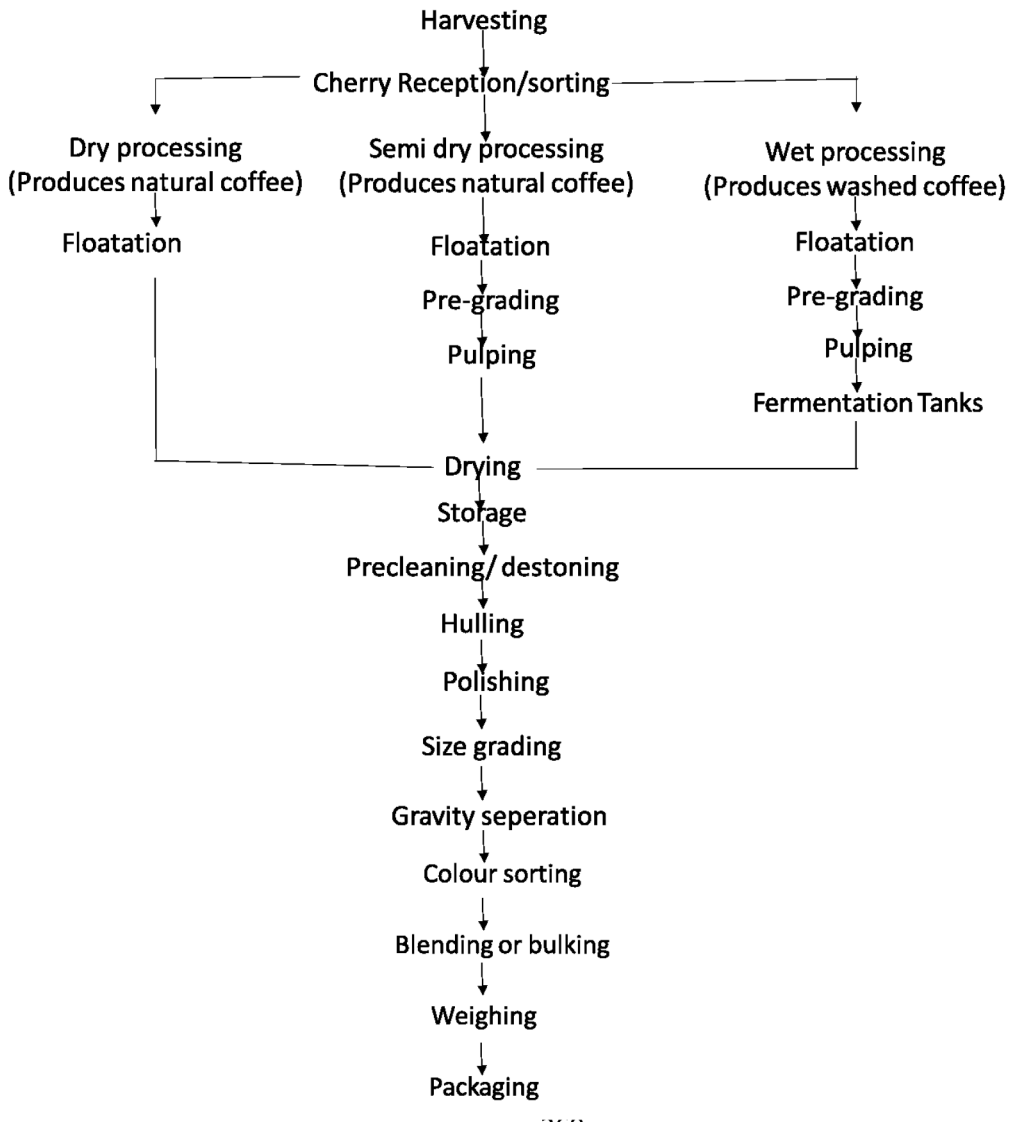
5.11. Food Quality and Safety Standards related to Coffee

Coffee belongs to family Rubiaceae. The coffee plants yield within 3–5 years and last up to 30–40 years.

Chemical characteristics of coffee

Coffee contains some nitrogenous compounds, such as caffeine, trigonelline, betaine, choline, and ammonia. Of these, caffeine is the most important with respect to its concentration as well as its effect on human physiological characteristics.

Flowchart for green coffee processing



Key area of safety in coffee processing

Coffee beans should preferentially be stored as natural or parchment coffee, because in that way they retain the product quality properties. Inadequate storage conditions may confer odd flavors to the coffee liquor (e.g. woody, mouldy, etc). Beans should be kept in storage facilities for a minimum

period of 30 days. Facilities should be built in places with plenty of sunlight, ventilation and drainage, with a room temperature of 20oC and maximum air humidity of 65%. It is fundamental to keep the coffee beans at 11-12% moisture content, as they are highly hygroscopic, and can absorb air moisture if kept in environments with high humidity. It is also advisable that the storage facilities are dark, so that the coffee beans (especially hulled beans) do not lose their colour due to excessive light exposure.

5.12. Food Quality and Safety Standards related to Tea

The tea plant is cultivated in tropical and subtropical regions of varying climatic conditions: with a temperature range of 13°C–29°C, altitude 2460 m above sea level, and acidic soil rich in iron and manganese with a pH range of 3.3–6.0, preferably 4.5–5.5.

Types of tea

It is classified into conventional and non-conventional tea

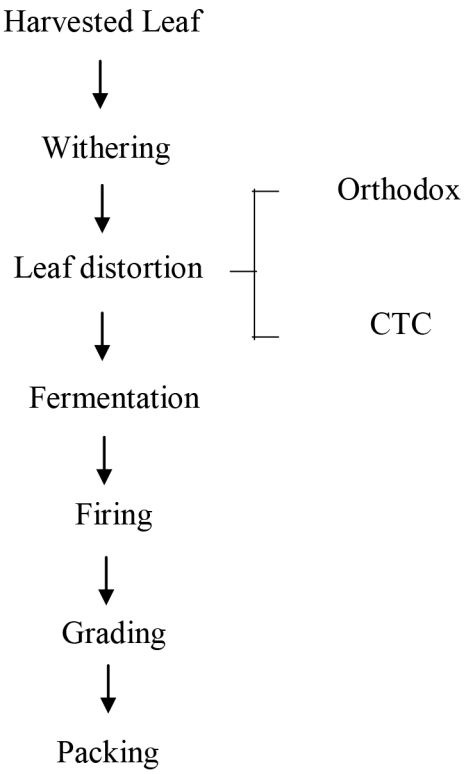
(a) Totally fermented black tea, (b) Raw or unfermented green tea, and (c) Partially fermented Oolong (red and yellow) tea and

Nonconventional tea products

(d) Instant tea, (e) Flavored tea, (f) Decaffeinated tea, (g) Canned or bottled tea, (h) Frozen tea liquid

(i) Tea tablets

Liquid tea concentrates, tea mixes, iced tea mixes, and fruit tea mixes have shown tremendous increase in the U.S. market. Decaffeinated tea, both plain and flavored, is finding expanding markets in the United States, United Kingdom, Germany, and other countries.



Flowchart for processing of tea

Grading and Storage

Tea is often winnowed to remove stalky material and sieved to obtain different grades, which are based on particle size. Chemical changes take place during the storage of finished tea products, which tend to lose all residual greenness and harshness within a few weeks time. Tea remains sound and full of flavor for more than 1 year, if kept in a cool place and protected from moisture and oxygen.

There are four main grades for black tea:

1. Orange Pekoe (OP)

Is a whole leaf tea showing no tip and will not pass through a certain designated sieve size. These leaves are usually of uniform size and rolled lengthways. Tippy Golden Flowery Orange Pekoe (TGFOP) is the top grade. During harvesting the top two leaves and bud are plucked by hand. The bud is actually the immature leaf tip which is not yet fully opened.

2. Broken Orange Pekoe (BOP)

It is the next grade below Orange Pekoe which designates a broken leaf. Tippy, golden, and flowery or a combination of these terms may also be applied to this size of leaf. Thus a grade of 'TGBOP' is a Tippy Golden Broken Orange Pekoe tea.

3. Fanning (F)

It is smaller than BOP. This is a broken leaf about the size of a pin head.

4. Dust (D)

This size is literally the smallest broken pieces left after siftings, sometimes called the 'sweepings' and only used for tea bags.

The grading of green and oolong teas is a little more subtle and less structured than that of black teas. Unlike black teas the grading of green tea has a definite relationship with the quality and flavour of the tea.

1. Whole LeafYH Young Hyson
2. FYH Fine Young Hyson
3. Broken GP Gun Powder
4. H Hyson
5. FH Fine Hyson
6. Fannings SOUMEE Soumee

Under-fermented tea - Thermal treatment of under-fermented teas in a factory or storehouse by

ambient temperatures that reach 40°C is practiced in many parts of the world, particularly in China and India. Thermal treatment eliminates the grassy odor and coarse taste in the unfermented teas that are due to polyphenols, catechins, and other constituents present in high proportions. Thermal treatment results in isomerization and epimerization of catechins, degradation of chlorophyll, and synthesis of aldehydes and essential oils and improves the flavor quality of manufactured tea.

Manufacturing of Green Tea

The steps until withering is followed as that of black tea after that steaming, cooling, first rolling, rolling and twisting, second rolling, final rolling and drying is practiced for green tea production.

Manufacturing of Oolong Tea

Oolong tea is semi-fermented tea. The process generally involves solar withering, in-door withering, parching, rolling and drying.

Harvesting

↓

Solar withering (20 min)

↓

In-door withering (2 – 4 h)

↓

Shaking

↓

Parching, rolling, drying

↓

Firing

↓

Oolong tea

The shaking ruptures the leaves and fermentation or oxidation begins, which is halted after 2 hours by firing process. In this short time, only 12-20 % fermentation occurs.

Colour – pale orange brown in colour (Chinese oolong tea)

Parching – pan or mechanical roasting of leaves around 100°C to inactivated enzymes

Firing – 100°C until the moisture reaches >6%

Key area of safety in tea manufacturing

Tea is a beverage prepared by infusing the dry tea leaf in water in most cases, boiling water is used but cold water can be used particularly when preparing 'iced tea'. Thus manufacturing process is one of the most important areas to be considered when considering the food safety hazards where it is important to consider each and every step in the manufacturing process for hazard assessment. Following potential food safety hazards were identified from primary production and processing of tea up to the packaging. No natural contamination is present in tea leaves but because of improper hygiene the following may be a cause for safety concerns

1. Chemical contamination can happen because of environmental pollution, inappropriate use of agrochemicals, sabotage, adulteration, lubricants from tea processing machinery, fumigant residues from the fumigation of containers and contamination during transport or storage.
2. Physical contamination - foreign matter
3. Tea has a long history of safe use and microbiological contamination is not reported. This may be attributed to its low moisture content (i.e. low water activity) and the high content of anti-microbial substances. Moisture levels up to 10% seem to give an acceptable safety margin for the storage of tea. Should a package become wet mould growth may occur and it can be physically observed as mould lumps

The hazard analysis needs to be applied according to the food safety system specific to customer requirements which is based on HACCP principles by tea manufacturer to each specific processing.

- Keep clean and, where necessary after cleaning, to disinfect, in an appropriate manner, facilities, equipment, containers, crates, vehicles and vessels;
- Ensure, where necessary, hygienic production, transport and storage conditions for, and the cleanliness of, plant products;
- Use potable water, or clean water, whenever necessary to prevent contamination; to ensure that staff handling foodstuffs are in good health and undergo training on health risks; to make certain that those who come directly in contact with tea leafs and tea are not likely to contaminate it by maintaining an appropriate degree of personal cleanliness (e. g. wash hands after eating, smoking etc.), and by behaving and operating in an appropriate manner; smoking should only be permitted in designated areas which are separated from any processing or storage areas
- Prevent animals and pests from causing contamination; to use plant protection products and biocides correctly, as required by the relevant legislation.
- Keep records on:
    - o any use of plant protection products and biocides
    - o any occurrence of pests or diseases that may affect the safety of products of plant origin

The primary producer may be assisted by other persons, such as, agronomists and farm technicians, with the keeping of records. International standards like ISO 3720:2011 specifies the parts of a

named plant that are suitable for making black tea for consumption as a beverage and the chemical requirements including polyphenol and caffine content for black tea, basics of good manufacturing practices but does not regulate pesticide residue limits but the standards are not applicable to scented or decaffeinated black tea.

HACCP of Green Coffee

Table 5.9: Hazard Analysis for the Pre-Harvest – Product: Coffee

Stages of the Process	Hazards	Justification	Severity	Risk	Preventive measures
Planting	Biological hazard: none Physical hazard: none Chemical hazard: none				
Cultivation/ Use of Pesticides	Biological hazard: none Physical hazard: none Chemical hazard: pesticide residues	Inadequate use or non accomplishment of the period to reach safe levels	High	Medium	GAP: Follow application procedures and accomplishment of agronomical recommendations and manufacturer's instructions
Cultivation/ Use of Mineral Fertilizers	Biological hazard: none Physical hazard: none Chemical hazard: none				
Cultivation/ Irrigation	Biological hazard: none Physical hazard: none Chemical hazard: none				
Harvest	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin	Damaged and spoiled fruits, in advanced stage of maturation facilitate development of Ochratoxin producing fungi	High	Medium	GAP: Pest control procedures, harvest in the right stage of maturation with majority of fruits in ripe cherry stage. Training and qualification of harvesting labor. Harvest planning, observing the uniformity of fruit maturation.

Date: Approved by:

Table 5.10: Hazard Analysis for the Post-Harvest – Product: Coffee

Stages of the Process	Hazards	Justification	Severity	Risk	Preventive measures
Wagging	Biological hazard: none Physical hazard: leaves, stones, sticks Chemical hazard: none	Frequent occurrence due to the stripping process	Medium	High	GAP: training and qualification, maintenance of wagging sieves.
Transpor-tation for Hulling	Biological hazard: none Physical hazard: none Chemical hazard: none				
Washing	Biological hazard: none Physical hazard: none Chemical hazard: none				
Separation	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin A (OTA)	Possibility of TA occurrence on floating coffee	High	Medium	Efficient separation and maintenance of separation of the floating coffee from the immature and ripe cherries, up to the end of the process. Training and qualification of operators.
Drying in terraces (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin A (OTA)	Contamination and/or development of OTA producing fungi	High	High	GAP: Terrace installations, hygiene programme, spreading procedures, piling up and turning over. Assurance of a fast and uniform drying process until maximum moisture content of 13%.
Bulk storage (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: insects and rodents Chemical hazard: Ochratoxin A (OTA)	Failure in the integrated pest control programme, allowing proliferation. Inadequate storage conditions (ventilation, humidity, temperature, etc) which favors development of OTA producing fungi.	Low Hihg	Medium High	GAP: MIP programme, installation hygiene. Good Storage Practices and control of conditions such as temperature and relative air humidity in the storage facility.

Packing in sacks (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: none Chemical hazard: none				
Expedition	Biological hazard: none Physical hazard: none Chemical hazard: none				

Date: Approved by:

Table 5.11: Determination of CP/CCP in the Pre-Harvest Stage – Product: Coffee

	zards (biological,	controlled by the ent programme? If tant to consider it as a CP?	Are there asures for	This stage reduces the ptable levels?	The hazard can o unacceptable er stage?	The hazard can or reduced to els in a later stage?	

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Cultivation/use of pesticides	CP (Q)	Pesticide residues	GAP: Procedures of application and accomplishment of agronomical recommendations and manufacturer's instructions	Obedience to the prescriptions of the manufacturer's agronomical recommendations	**What?** Use of pesticides. **How?** Visual observation. **When?** Each application. **Who?** Operator	Increase period of time to reach safe levels, equipment calibration; correction of solutions and application	spreadsheet	Training programme of usage and application procedures; supervision; Programme for sample collection and analysis; programme for equipment calibration.
Harvest	CP (Q)	Ochratoxin	GAP: Procedures for pest control; harvesting at the maturation stage with predominance of ripe cherries; training and qualification of harvesting labor; harvest planning, observing uniform maturation of the fruits.	Minimum of 70% ripe fruits.	**What?** Fruits **How?** Visual observation. **When?** During harvest **Who?** Harvesting labor.	Interrupt harvest; pick selectively only ripe cherries.	spreadsheet	Training and qualification programme; field supervision; harvest plan review.
floats)								

Date: Approved by:

Table 5.12: Determination of CP/CCP in the Post-Harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Wagging	CP (F)	Leaves, stones, sticks	GAP: Training and qualification; sieve maintenance.	4% impurities	**What?** Impurities. **How?** Visual observation. **When?** Each process. **Who?** Person in charge of the operation.	Reprocess (repeat wagging)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Separation	CP (Q)	Ochratoxin	Separate effectively and keep separation of the float coffee from the immature and ripe cherries; Training and qualification of operators.	Less than 2% of floats in the separated ripe cherries and immature fruits.	**What?** Floats **How?** Visual observation. **When?** Each separation **Who?** Person in charge of the operation.	Reprocess (repeat separation)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Terrace drying (ripe and immature cherries, and floats)	CCP1 (Q)	Ochratoxin	GAP: Terrace installations, hygiene programme, spreading procedures, piling up and turning over the coffee fruits on the terrace; assure a fast and uniform drying process until a maximum moisture content of 13%.	Maximum 13% moisture at the end.	**What?** Moisture **How?** Moisture meter. **When?** Daily. **Who?** Supervisor.	Optimize drying; increase the number of times coffee is turned over; decrease thickness of the layer of coffee beans; supplement with mechanical drying.	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses

Table 5.13: Summary of the HACCP Plan in the Pre-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Bulk storage (ripe and immature cherries, and floats)	CP (F)	Insects and rodents	GAP: MIP programme, installation hygiene.	Absence of pest evidence.	**What?** Pest evidence. **How?** Visual observation. **When?** Daily **Who?** Supervisor	Identify MIP	Pest evidence spreadsheet	Training and qualification programme; inspection.
	CCP2 (Q)	Ochratoxin	Good practices of storage and control of temperature and humidity inside the storage facility.	Maximum 13% moisture in the beans, maximum 70% humidity inside the storage facility.	**What?** Bean moisture and environment humidity. **How?** Moisture meter (beans) and hygrometer (environment) **When?** Daily. **Who?** Supervisor.	Correct environmental humidity (ventilation); Reprocess coffee drying.	Bean moisture and environment humidity spreadsheet	Supervision, spreadsheet analysis; programme for sample collection and analyses of OTA and moisture.

prescriptions of

Date: Approved by:

Table 5.14: Summary of the HACCP Plan in the Post-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Wagging	CP (F)	Leaves, stones, sticks	GAP: Training and qualification; sieve maintenance.	4% impurities	**What?** Impurities. **How?** Visual observation. **When?** Each process. **Who?** Person in charge of the operation.	Reprocess (repeat wagging)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Separation	CP (Q)	Ochratoxin	Separate effectively and keep separation of the float coffee from the immature and ripe cherries; Training and qualification of operators.	Less than 2% of floats in the separated ripe cherries and immature fruits.	**What?** Floats **How?** Visual observation. **When?** Each separation **Who?** Person in charge of the operation.	Reprocess (repeat separation)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Terrace drying (ripe and immature cherries, and floats)	CCP1 (Q)	Ochratoxin	GAP: Terrace installations, hygiene programme, spreading procedures, piling up and turning over the coffee fruits on the terrace; assure a fast and uniform drying process until a maximum moisture content of 13%.	Maximum 13% moisture at the end.	**What?** Moisture **How?** Moisture meter. **When?** Daily. **Who?** Supervisor.	Optimize drying; increase the number of times coffee is turned over; decrease thickness of the layer of coffee beans; supplement with mechanical drying.	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses

Table 5.15: Summary of the HACCP Plan in the Post-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Bulk storage (ripe and immature cherries, and floats)	CP (F)	Insects and rodents	GAP: MIP programme, installation hygiene.	Absence of pest evidence.	**What?** Pest evidence. **How?** Visual observation. **When?** Daily **Who?** Supervisor	Identify MIP	Pest evidence spreadsheet	Training and qualification programme; inspection.
	CCP2 (Q)	Ochratoxin	Good practices of storage and control of temperature and humidity inside the storage facility.	Maximum 13% moisture in the beans, maximum 70% humidity inside the storage facility.	**What?** Bean moisture and environment humidity. **How?** Moisture meter (beans) and hygrometer (environment) **When?** Daily. **Who?** Supervisor.	Correct environmental humidity (ventilation); Reprocess coffee drying.	Bean moisture and environment humidity spreadsheet	Supervision, spreadsheet analysis; programme for sample collection and analyses of OTA and moisture.

CHAPTER 6

SOFT SKILLS AND COMMUNICATION

The role of communication skills cannot be undermined when studying the corporate soft skills (CSS) needs of the stakeholders. It is important to note that the major language of corporate world is English and graduates all over the world who aspire to make it big in their career need to improve their English language proficiency. But one's language skills alone cannot make him / her successful in one's career as there are other soft skills like assertiveness, team management, presentation skills etc. too which are equally important. Soft skills are a set of skills that influence how we interact with each other. It includes personal and social skills like effective communication, creativity, analytical thinking, diplomacy, flexibility, change-readiness, problem-solving and listening skills. It also includes a lot of business skills like communication and presentation, leadership and management, human resources, sales and marketing, team building, professional development, project management, time management, customer service, administration and personal development. Wikipedia defines soft skills in the following way:

"Soft skills are a sociological term relating to a person's "EQ" (Emotional Intelligence Quotient), the cluster of personality traits, social graces, communication, language, personal habits, friendliness, and optimism that characterize relationships with other people. Soft skills complement hard skills (part of a person's IQ), which are the occupational requirements of a job and many other activities."

The importance of soft skills as distinct from hard skills is increasingly being recognized in several sectors of today's highly competitive world. Soft skills play a vital role in one's professional success. They help a professional to excel in the workplace and their importance cannot be denied in this age of information technology. Soft skills complement the hard skills, which are the technical requirements of a job, and are essential for success in the challenging work place environment.

Soft skills are a combination of people skills, emotional skills, communication skills, and interpersonal skills. Typically, soft skills are inherent to a particular person, and are not exactly "teachable." While a "hard skill" might be the knowledge of CSS, a "soft skill" is something less quantifiable. However, soft skills are incredibly important, especially in the alternative office spaces

or flexible work environments that are becoming increasingly commonplace. The soft skills could include leadership, willingness to learn new skills, positive attitude, adaptability, and problem-solving.

Communication soft skills are the tools you use to clearly and effectively converse with others, set expectations, and work with others on projects. Whether you're a CEO or an entry-level employee, communication skills are of utmost importance. Verbal and written communication comes into play every day at the workplace. Make sure you are communicating to the benefit of forward movement of both your company and your career. Here are some of the most important communication soft skills and how to apply them no matter what your role is.

6.1. Listening soft skills

We are starting with listening for an important reason. Before you ever open your mouth or put pen to paper, whether in a brand new position or within a seasoned leadership role, you should always listen first.

Listening as a soft skill is just as important on day one as it is on day 2,000. As humans, we can always learn from new experiences. Assumptions are the enemy of real growth.

Listening as a New Employee

If you are brand new at a company, you might feel a little lost. Some workplaces have processes in place that move fast and, therefore, are hard to fold seamlessly into on your first day. Listen and learn. Take your first few weeks to listen to your new coworkers, to learn the ropes, to ask questions, and to take it all in. Don't jump the gun. When the time comes to give meaningful input, you will have gathered valuable information and advice to disperse to your new team.

Listening as a Manager

So, you've been at your job for five years. You know your team like the back of your hand (whatever that means) and you know everything about how your department "should" run. Well, that's what you think. A good leader will know what is going on from day to day. A good manager will be present and aware. A great manager, however, will be listening for feedback and gathering information from her team on how to improve and iterate.

- Do you listen to your team?
- Do you check in to make sure workloads are appropriate?
- Do you make sure your team has enough work to remain productive, but not so much that they burn out quickly?

As a manager, make listening part of your weekly routine. Carve weekly 1:1 individual meetings with each of your team members in order to provide an open forum. Use this time to listen and learn from your employees.

6.2. Verbal communication soft skills

Verbal communication is something that comes more naturally to certain people—and it's a highly

ranked skill in the workplace. Starting with an initial phone interview, verbal communication will be a soft skill you need to hone, no matter what your role is.

Verbal Communication at a New Job

In a new position, verbal communication will come into play almost immediately. While you may feel intimidated speaking up in a new workplace, you'll want to take opportunities to enunciate clearly, to ask questions, and to state your needs and wants. By establishing a communicative position from the get-go, you are telling your managers that you are both open to feedback and that you will not hesitate to interface should any issues arise in the future.

Verbal Communication as a Manager

Careful verbal communication is essential for a great manager. Be mindful when speaking with your employees. Whether you are having a casual conversation, a discussion about a client, a brainstorm on a project, or (gulp) a disciplinary discussion, verbal communication is extremely important.

In each of these situations, consider your employee's perspective. Formulate your input and responses while keeping your employee's point of view in mind. Pay attention to your non-verbal communication, too. Consider your eye contact, body language, facial expressions, and especially the words you use. If you have used your time as a manager to foster a relationship of understanding, then you will be well-equipped to have open, respectful conversations with your employees- even if the conversation is on the tougher side.

Written Communication as an Employee

The word "covering my behind" is to always over-communicate, especially in emails and correspondences. We often worked with a bevy of clients across many industries, many of whom were extremely busy. I learned pretty quickly that things could easily fall through the cracks. As an entry or mid-level employee, these oversights will usually come down on you. If you do your job, pay attention to details, and leave a written paper trail (i.e. emails), you can always have you behind essentially covered. Next time your client misses a deadline or your boss forgets to follow up, you will be ready to go with that super-smug greeting, "As per my email dated February 22nd …"

Written Communication as a Manager

Covering your behind is a skill you will absolutely want to take into the management level. As a manager, it is your responsibility to communicate well with your employees. Written communication is not always the best type of communication to cover all bases. Some things are better verbally communicated for clarity and tone. However, written summaries, whether by emails or living documents, serve as great supplemental elements to lengthy meetings, complicated projects, or workloads that include a ton of deadlines. As a manager, it is also important to consider what you are putting into writing. Make sure your written correspondences are always responsible, respectful, and professional.

6.3. Presentation soft skills

Presentation soft skills come naturally to some people. But if you tend to be more of an introvert, presentation soft skills may be something less natural or downright uncomfortable for you. Consider this: presentation skills are nothing more than a culmination of other communication soft skills. Presentation skills are a combination of listening, verbal, and written communications in one go.

Presentation Soft Skills as an Employee

Presenting anything in front of a group of people makes me pretty nervous. However, I also realize that it's downright silly to be that intimidated by anyone. We are all people. We all get nervous sometimes. Shake it off! So, you have been asked to present something to your coworkers or a client. Think about why you were asked to present. It is likely because you are the expert on that topic. Let that wash over you for a minute.

When you are assembling your presentation, think of what you can actually teach your audience. Is it a complicated marketing initiative that you built yourself? Is it a report on how your company's social engagement has skyrocketed? Fuel your presentation with your successes. Put all that nervousness or imposter syndrome creepiness to bed.

Presentation Soft Skills for a Manager

If you're in a management role, it is likely that you already have ample presentation soft skills. You're likely more comfortable interfacing with several people at one time; at ease when communicating complicated ideas or projects. For a manager, presentations are a great opportunity to showcase your listening skills. Are you communicating ideas that your entire team can digest and understand? Have you organized ideas and steps in a way that the entire team will understand? Next time you are assembling a presentation as a manager, think of your employees or clients. Recall conversations you had with them. Recall their concerns, their goals, and what excited them. If you showcase your listening skills within your presentation, you'll have had a successful meeting. The way you communicate with your sister is (hopefully) different than the way you communicate with your boss. The way you write a birthday card is different than the way you write an email to a client. Always pay attention to the way you communicate. A simple email could be the only impression another person gets from you.

- What language are you using?
- Are you apologizing too much?
- Are you friendly?
- Are you stern?
- Are you providing others space with which to communicate to you?

By always considering the way you communicate, you'll advance both personally and professionally. The most sought after skills by the employers are communication skills, interpersonal abilities,

positive attitude, team work, leadership skills, planning and organising skills. The feedback from the employers indicated that though the test scores in the communication skills course showed 100% results compared to the pass percentage of 87% in the Technical English course, there were limitations as the students faced difficulties during the recruitment process as they exhibited lack of specific skill sets sought by the recruiters. The curriculum designers of the University have realized that the communication skills training module and the soft skills training are not a single step process and it is best started in the freshmen year and is also taught in the entire degree programme, this gives ample time and scope to put into practice the skills learnt. The communication and soft skills is an essential tool for achieving sustainability and success in career worldwide. An effective communication skill helps to deliver the idea clearly, effectively and with confidence either orally or in writing. Critical thinking and problem solving skills helps to think beyond and also it helps to have the ability to understand and accommodate oneself to the varied working environment. Interpersonal skills help to build a good rapport, interact and work effectively as a team. Leadership skills pertain to the ability to understand and take the responsibility of a leader. Many research studies have shown that to be successful in the workplace, technical skills alone are not enough. Soft skills are also needed to deal with the external world. In the highly competitive corporate world, it is one's soft skills that give one an edge over others. Many studies have shown that long term job success for any professional is mainly due to one's soft skills rather than one's technical skills.

Soft skills are classified as core soft skills and corporate soft skills. The core soft skills are the skills related to personal qualities such as responsibility, self-esteem, sociability, self-management and integrity. These skills define the human side of doing business and are very critical in building the mental resilience required to handle the dynamic dimensions of the corporate world. The corporate soft skills are interpersonal skills such as effective communication, delegation, negotiation, decision making and team building. The core soft skills form the premise to develop corporate soft skills. Soft skills are increasingly sought out in the business world in addition to standard qualifications. The core soft skills are those that are required for 'life' and that the corporate soft skills are for a 'living'. Well-documented studies conducted by Harvard University and Stanford Research Institute report that technical skills and knowledge contribute to only 15 per cent of one's success while soft skills make up the remaining 85 per cent. People, who rank highly with good soft skills, are generally the people that most employers want to hire, retain and promote. Technical and job-related skills are a must, but they are NOT sufficient when it comes to progressing up the ladder. Superior performance depends on how well an individual handles himself / herself and others around the workspace. Soft skills therefore complement the hard skills. In conclusion, soft skills are like a living organism in that they shift constantly. Communication is an ever-changing landscape, too.

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