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

Training for Master Trainers

Hand Book of Grain Processing

Organized by
CSIR-Central Food Technological Research Institute
Mysore- 570 020, Karnataka

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VOCAL FOR LOCAL

सत्यमेव जयते

MINISTRY OF FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

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Abbreviations and Acronyms

DPR	Detailed Project Report
DLC	District Level Committee
FPI	Food Processing Industry
FPO	Farmer Producer Organisation
FUP	Firm level Upgradation Plan
GOI	Government of India
FME	Formalization of Micro Enterprises
IA	Implementing Agency
IMEC	Inter Ministerial Empowered Committee
IIFPT	Indian Institute of Food Processing Technology
MIS	Management Information System
MOFPI	Ministry of Food Processing Industries
MoU	Memorandum of Understanding
MSDE	Ministry of Skill Development and Entrepreneurship
MSME	Micro, Small and Medium Enterprise
NABARD	National Bank for Agriculture and Rural Development
NCDC	National Co-operative Development Corporation
NIFTEM	National Institute for Food Technology Entrepreneurship and Management
NGO	Non-governmental Organizations
NRLM	National Rural Livelihood Mission
ODOP	One District One Product
PEC	Project Executive Committee
PIP	Project Implementation Plan
PMU	Project Management Unit
PMKSY	Pradhan Mantri Kishan Sampada Yojana
PMU	Project Management Unit
R&D	Research and Development
RP	Resource Person
SC	Schedule Caste
ST	Schedule Tribe
SHG	Self Help Group
SIDBI	Small Industries Development Bank of India
SLAC	State Level Approval Committee
SNA	State Nodal Agency
SRLM	State Rural Livelihood Mission
TOR	Terms of Reference
UT	Union Territory

Background

Overview

- 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 enterprises contribute to 74% 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 enterprises[1]. Most of these units falls 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 skill training, entrepreneurship, technology, credit and marketing, across the value 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 upgradation and formalization of these enterprises.

1. Aims

The scheme aims to:

i) Enhance the competitiveness of existing individual micro-enterprises in the unorganized segment of the food processing industry and promote formalization of the sector; and

ii) Support Farmer Producer Organizations (FPOs), Self Help Groups (SHGs) and Producers Cooperatives along their entire value chain.

2. Objectives

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

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

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

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

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

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

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

3. Outlay

The scheme envisages an outlay of Rs. 10,000 crore 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.

4. 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.

Programme Components

The programme has four broad components addressing the needs of the sector:

i) Support to individual and groups of micro enterprises;

ii) Branding and Marketing support;

iii) Support for strengthening of institutions;

iv) Setting up robust project management framework.

Details of each of these components are described below.

Support to Individual Micro Enterprises

Individual micro food processing units would be provided credit-linked capital subsidy @35% of the eligible project cost with a maximum ceiling of Rs.10.0 lakh per unit. Beneficiary contribution should be minimum of 10% of the project cost with balance being loan from Bank.

Eligibility criteria for individual micro enterprises under the scheme:

i) Existing micro food processing units in operations;

ii) Existing units should be those identified in the SLUP for ODOP products or by the Resource Person on physical verification. In case of units using electrical power, electricity bill would support it being in operations. For others units, existing operations, inventory, machines and sales would form the basis;

iii) The enterprise should be unincorporated and should employ less than 10 workers;

iv) The enterprise should preferably be involved in the product identified in the ODOP of the district. Other micro enterprises could also be considered;

v) The applicant should have ownership right of the enterprise;

vi) Ownership status of enterprise could be proprietary / partnership firm;

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

viii) Only one person from one family would be eligible for obtaining financial assistance. The “family” for this purpose would include self, spouse and children;

ix) Willingness to formalize and contribute10% of project cost and obtain Bank loan;

x) Cost of the land should not be included in the Project cost. Cost of the ready built as well as long lease or rental workshed could be included in the project cost. Lease rental of workshed to be included in the project cost should be for a maximum period of 3 years only.

Selection Process for Individual Micro Units

- Identification of existing Units to be supported would be by a two-pronged process. Based on One District One Product approach, support would preferably be provided to the Units engaged in that product in the district. Other units, who have potential, would also be supported.

- Applications would be invited at the district level on an ongoing basis for Units, from those interested in availing the benefits under the Scheme. Resource Persons (RPs) would undertake survey of various clusters and identify units that show potential for availing benefits under the Scheme. For applications received directly, RPs would undertake field verification and due diligence to assess their potential.
- All the potential cases based on identification of Units directly by RPs and application received would be submitted before the District Level Committee. District Level Committee should study the report submitted by RP for each Unit and interview the interested persons.
- Due diligence to be carried out by the RP for each Unit should have the following details:
    - Annual Turnover of the enterprise;
    - Track Record of payments by the enterprise;
    - Existing infrastructure;
    - Backward and Forward Linkages;
    - Proximity to clusters;
    - Marketing linkages of the enterprise.
- For the cases recommended by the District Level Committee/SNA, RPs should help them in preparation of DPR for availing bank loan for upgradation of the Unit. The DPR along with necessary documents should be submitted to the Banks for sanction of loan.
- The procedure delineated above would apply for selection of new units also, provided the ODOP baseline study throws up a need / potential for such new investments.
- State Governments should decide at what level they would want to finalize individual micro units list to be supported, by DLC or at SNA level. Similarly, for applications for capital investment by groups, common infrastructure & marketing & branding, the states should decide the role of DLC/SNA in routing of applications.

Group Category

The Scheme would support clusters and groups such as FPOs/SHGs/ producer cooperatives along their entire value chain for sorting, grading, assaying, storage, common processing, packaging, marketing, processing of agri-produce, and testing laboratories.

Farmer Producer Organizations (FPOs)/Producer Cooperatives

FPOs and Producer Cooperatives would be provided the following support:

i) Grant @35% with credit linkage;

ii) Training support;

iii) Maximum limit of grant in such cases would be as prescribed.

Eligibility Criteria for Co-operatives/FPOs:

iv) It should preferably be engaged in processing of ODOP produce;

v) It should have minimum turnover of Rs.1 crore;

vi) The cost of the project proposed should not be larger than the present turnover;

vii) The members should have sufficient knowledge and experience in dealing with the product for a minimum period of 3 years.

viii) The cooperative/FPO should have sufficient internal resources or sanction from the State Government to meet 10% of the project cost and margin money for working capital;

Self Help Groups (SHGs)

A number of SHGs are undertaking food processing activities. The Scheme proposes to provide following support to SHGs:-

Seed capital:

ix) Seed capital @ Rs40,000/- per member of SHG for working capital and purchase of small tools would be provided under the scheme;

x) Priority would be given for SHGs involved in ODOP produce in giving seed capital;

xi) All the members of an SHG may not be involved in the food processing. Therefore, seed capital would be provided at the federation level of SHGs;

xii) This would be given as grant to the SHG federation by SNA/ SRLM. SHG federation would provide this amount as a loan to the members of SHGs to be repaid to the SHG.

Support to individual SHG member as a single unit of food processing industry with credit linked grant @35% with maximum amount being Rs 10 lakh.

Support for capital investment at federation of SHG level, with credit linked grant @35%. Maximum limit of grant in such cases would be as prescribed.

Training & Handholding Support to SHGs: For support to SHGs, a large number of trained resource persons are available with State Rural Livelihood Missions (SRLMs). These local resource persons of SRLM having expertise in agro-produce would be utilized for training, upgradation of units, DPR preparation, handholding support, etc.

Eligibility Criteria for Seed Capital for SHGs:

xiii) Only SHG members that are presently engaged in food processing would be eligible;

xiv) The SHG member has to commit to utilize this amount for working capital and purchase of small tools and give a commitment in this regard to the SHG and SHG federation;

xv) Before providing the seed capital, SHG Federation should collect the following basic details for each of the members:

a) Details of the product being processed;

b) Other activities undertaken;

c) Annual turnover;

d) Source of raw materials and marketing of produce.

Eligibility Criteria for Credit Linked Grant for Capital Investment for SHGs:

xvi) The SHGs should have sufficient own funds for meeting 10% of the project cost and 20% margin money for working capital or sanction of the same as grant from the State Government;

xvii) The SHG members should have for a minimum period of 3 years' experience in processing of the ODOP product.

Support for Common Infrastructure

Support for common infrastructure would be provided to FPOs, SHGs, cooperatives, any Government agency or private enterprises. Common infrastructure created under the scheme should also be available for other units and public to utilize on hiring basis for substantial part of the capacity. 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%. Maximum limit of grant in such cases would be as prescribed.

Types of Common infrastructure to be funded under the scheme: The following common infrastructure would be funded under the Scheme:

i) Premises for assaying of agriculture produce, sorting, grading, warehouse and cold storage at the farm-gate;

ii) Common processing facility for processing of ODOP produce;

iii) **Incubation Centre** should involve one or more product lines, which could be utilized by smaller units on a hire basis for processing of their produce. The Incubation Centre may partly be used for training purpose. It should be run on commercial basis.

Procedure for groups to send proposals for Common Infrastructure and capital investment by FPOs/SHGs/Cooperatives:

The following procedure should be followed for seeking funding for common infrastructure and capital investment by FPOs/SHGs/Cooperatives under the Scheme:

i) A DPR for seeking assistance under the Scheme for capital investment and common infrastructure should be prepared, based on the format as prescribed;

ii) The DPR should have necessary details of the proposal, detailed project cost, proposed manpower, turnover, marketing channel, sources of raw material, estimated profit & loss account, cash flow statement, etc.;

iii) The DPR should be sent to State Nodal Agency (SNA). After approval of the proposal by SLAC, SNA should recommend the proposal to MoFPI. Any proposal for assistance to a group for grant above Rs.10 lakh should be sent to MOFPI for approval.

iv) After approval of the proposal by MoFPI, the proposal should be forwarded to the financial institution for sanction of loan;

v) The DPR may also contain proposal for training support to the group members based on the training hours & modules, as prescribed and the cost norms of Ministry of Skill Development and Entrepreneurship. Component of training and capacity building would be fully funded under the Scheme;

vi) Assistance of Rs. 50,000/- per case would be provided to FPOs/SHGs/ Cooperatives for preparation of DPR;

vii) Disbursement of grant should take place to the bank account of the applicant organization after sanction of loan by the bank.

Branding and Marketing Support

Marketing and branding support would be provided to groups of FPOs/SHGs/ Cooperatives or an SPV of micro food processing enterprises under the Scheme. Following the ODOP approach, marketing & branding support would only be provided for such product at the State or regional level.

Eligible items for support

i) Training relating to marketing to be fully funded under the scheme;

ii) Developing a common brand and packaging including standardization to participate in common packaging;

iii) Marketing tie up with national and regional retail chains and state level institutions;

iv) Quality control to ensure product quality meets required standards.

- Support for marketing and branding requires developing a common brand, common packaging and product standardization. The appropriate level for common branding and packaging would differ from place to place, case to case and product to product. Whether it should be district, regional or state level would be decided by the concerned SNA in each case. Therefore, the proposal for support to marketing and branding should be prepared by the SNA. Support for branding and marketing would be limited to 50% of the total expenditure. Maximum limit of grant in such cases would be as prescribed. No support would be provided for opening retail outlets under the scheme.
- Vertical products at the national level could also be provided support for branding & marketing on the same lines as described above for ODOP focus. Such support for common branding/packaging and marketing would be provided at the national level. Proposal for that support should be sent to MoFPI by the states or national level institutions or organizations or partner institutions.

Eligibility criteria:

The proposals should fulfill the following conditions:-

i) The proposal should relate to ODOP;

ii) Minimum turnover of product to be eligible for assistance should be Rs 5 crore;

iii) The final product should be the one to be sold to the consumer in retail pack;

iv) Applicant should be an FPO/SHG/cooperative/ regional - State levels SPV to bring large number of producers together;

v) Product and producers should be scalable to larger levels;

vi) Management and entrepreneurship capability of promoting entity should be established in the proposal.

Procedure for applying for assistance under Branding & Marketing

Detailed Project Report preparation:

i) A DPR should be prepared for the proposal, comprising essential details of the project, product, strategy, quality control, aggregation of produce, common packaging and branding, pricing strategy, promotional details, warehousing and storage, marketing channel, plans for increase in sales etc.;

ii) Support up to Rs.5 lakh would be available from SNA for preparing DPR for proposals for marketing & branding;

iii) The proposal should also contain flow chart of activities from the procurement of raw material to marketing, critical control points, ensuring quality control,

plans for five years in terms of promotional activities, increasing the number of participating producers and turnover;

7.6.2 There should be an agreement with a business plan, executed between the cooperatives/SHG/FPO/SPV, the lead buyer(s), if any, and the SNA, which would describe the capital and services needs of the producers and proposed improvements that would allow them to upgrade their production capacities and skills to strengthen their linkage with the market, i.e. the lead buyer(s).

Capacity Building & Research

Support to National Institutions:

Capacity building and training is a critical component in technical upgradation and formalization of micro food processing enterprises. At the National level, National Institute for Food Technology Entrepreneurship and Management (NIFTEM) and Indian Institute of Food Processing Technology (IIFPT) would play pivotal role in capacity building & research. They would be eligible for financial assistance towards research and capacity building. NIFTEM and IIFPT in partnership with State Level Technical Institutions would provide training and research support to the selected enterprises/groups/clusters. National level product specific institutions under ICAR, CSIR or premier institutes like DFRL and CFTRI will be partner institutions for providing support at the vertical level across the country for training and research.

NIFTEM and IIFPT would carry out the following activities**:**

i) Capacity building and training for MoFPI, State and District officials;

ii) Developing curricula and training modules and partner with State Level Technical Institutes for further trainings to micro enterprises and groups;

iii) Training of trainers;

iv) Development of online modules for training;

v) Preparation of standard Detailed Project Reports (DPRs) for typical products for micro units;

vi) Development of shelf of technology/ machines for up-gradation of typical micro units;

vii) Partnership with other research and training institutions for the above activities;

viii) Strengthening State Level Technical Institutions for delivery of the Scheme requirements.

NIFTEM and IIFPT would establish a PMU in their organization for the Scheme with composition as prescribed. For these PMUs, they would engage personnel on

contract basis. Grant under the Scheme would be provided to NIFTEM and IIFPT to meet full cost of these PMUs.

NIFTEM and IIFPT should prepare Project Implementation Plan (PIP)for the activities they propose to undertake along budget and submit to MoFPI. Committee for Capacity Building & Research at MoFPI would examine the PIPs and seek approval of IMEC for them. MoFPI would provide funding support under the Scheme to NIFTEM and IIFPT for the activities approved in the PIPs.

Support to State Level technical Institutions

State Government should nominate a State Level Technical Institution for the Scheme. Their activities would include:

ix) Prepare PIP for the State Level Technical Institution;

x) Providing inputs to PIP being prepared by the SNA relating to capacity building and research;

xi) Conducting capacity building and training for State and District officials;

xii) Conducting training for District Resource Persons;

xiii) Provide inputs for Branding and Marketing plans being prepared by SNAs;

xiv) Provide mentoring support to District Resource Persons for handholding micro enterprises, preparations of DPRs, etc.

The nominated State Level Technical Institution should prepare PIP including annual training calendar for the proposed activities and send that to MoFPI after approval from the State Level Approval Committee in consultation with the NIFTEM and IIFPT.

Criteria for selection of State Level Technical Institution: The State Level Technical Institution should be an existing institution involved in food processing technology. This Institute could be:

xv) A college/institute under State Agriculture University or any other University;

xvi) A State-owned food processing technology research Institute;

xvii) An institute under CSIR or any Government of India institute focusing on food processing;

xviii) If it is a college, it should have undergraduate/post graduate courses in food processing technology and necessary faculty;

xix) The Institute should have a full-fledged laboratory with necessary testing and processing equipment;

xx) The Institute should have faculty undertaking research work and product development and machinery for food processing, especially for MSMEs;

xxi) The proposal should be recommended by the State Government;

xxii) The Institute should be willing to appoint a Nodal Officer and a dedicated team consisting of at least two faculty members focusing exclusively on the Scheme;

xxiii) The Institute should have sufficient built-up space to undertake training for beneficiaries under the Scheme;

xxiv) The institute preferably should have pilot plants for processing few products under ODOP for the State.

Training support to individuals/groups

Training support would be provided to individual units and groups that are being provided support for capital investment. In addition, training support would also be provided to other existing units and groups in the districts that are processing ODOP products. Groups that are being provided support for marketing & branding under the Scheme would also be provided training support.

Ministry of Skill Development & Entrepreneurship (MSDE)have fixed per hour rate to be spent on trainings. The same benchmark rate would be utilized for the Scheme. Type of training and number of hours of training should follow the prescribed norms.

The following are the focus areas for capacity building under the Scheme:

xxv) Entrepreneurship development, essential functions of enterprise operations, marketing, book keeping, registration, FSSAI standards, Udyog Aadhar, GST Registration, general hygiene, etc.;

xxvi) Specific training designed for ODOP product or the product produced by the unit including operations of necessary machines, hygiene issues, packaging, storage, procurement, new products development etc.;

Mode of Training

xxvii) Online modules would be used for the general training applicable to all Units;

xxviii) Product specific training would be provided for the districts for ODOP using RSETI physical infrastructure to the extent possible;

xxix) Training should be organized in short modules on a weekly basis using audio-visual support within the district so that the disturbance to the existing business operations is least;

xxx) An important component of the training would be work on the machines that Units are going to purchase and training on hygiene and packaging. Therefore, a specific component for training is being introduced for such beneficiaries in the existing units using those machines within the district or outside for a short duration.

Handholding Support: The Scheme envisages engaging Resources Persons (RPs) at the district/ regional level for providing hand-holding support to the micro food processing enterprises. These RPs would carry out the following functions:

xxxi) Handholding micro enterprises in preparation of DPRs, getting bank loan, training, upgradation of the unit, getting necessary regulatory approvals, hygiene, etc.;

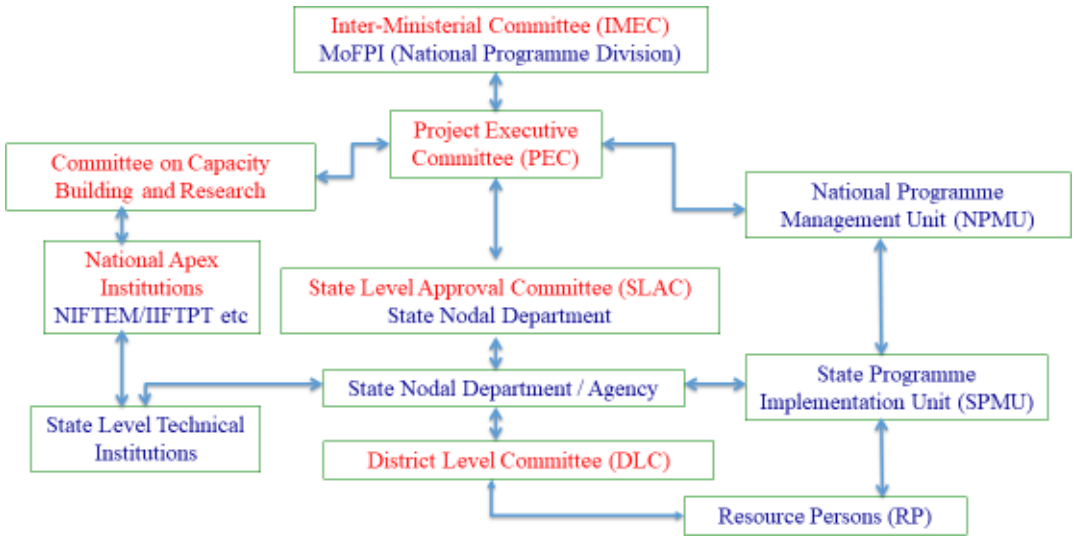
xxxii) Provide inputs for PIPs and ODOP and Cluster studies and study of groups;

xxxiii) Identification and facilitation of applications for subsidies and seed capital to individual micro enterprises and groups and common facilities;

Institutional Architecture

Robust institutional architecture at all administrative levels would be set up for the scheme. There would be committees at the National, State and District levels (for policy guidance) for implementation and to monitor the progress of the Scheme. These committees would oversee the performance of the National Programme Division at MoFPI and the State Nodal Agencies. In addition to these, there would be PMUs set up comprising consultants and experts engaged on full time basis to support the National Programme Division at MoFPI and the State Nodal Agencies. Institutional structure is illustrated in the chart below and described in the section below:

Figure 1: Institutional Architecture



National Level Structures
Inter-Ministerial Empowered Committee:

At the national level, there would an Inter-Ministerial Empowered Committee (IMEC) chaired by Minister for Food Processing Industries with the following composition.

Table 1: Composition of IMEC

	Composition	**Designation**
1.	Hon'ble Minister of Food Processing Industries	Chairman
2.	Hon'ble Minister of State of Food Processing Industries	Vice Chairman
3.	Secretary, Ministry of Food Processing Industries, Government of India (GoI)	Member
4.	Secretary, Department of Agriculture, Co-operation, & Farmers' Welfare, GoI	Member
5.	Secretary, Department of Animal Husbandry and Dairying, GoI	Member
6.	Secretary, Department of AgricultureResearch and Education, GoI	Member
7.	Secretary, Department of Fisheries, GoI	Member
8.	Secretary, Department of Urban Development & Housing, GOI	Member
9.	Secretary, Ministry of Rural Development, GoI	Member
10.	Secretary, Ministry of Skill Development & Entrepreneurship	Member
11.	Secretary, Ministry of MSME, GoI	Member
12.	Chairman, FSSAI	Member
13.	Chairman, NSDC	Member
14.	Representative of NABARD	Member
15.	AS&FA, Ministry of Food Processing Industries	Member
16.	Representative of NITI Aayog	Member
17.	Mission Director, (Officer of the rank of Additional/ Joint Secretary and above), Ministry of Food Processing Industries.	Member Secretary

MoFPI may nominate any other member to IMEC, PEC and Committee on Capacity Building & Research. The IMEC would meet at least once in a quarter and would be the policy making body giving overall direction and guidance for implementation of the scheme and would monitor and review its progress and performance.

Functions of IMEC would be:

i) Approval of the following:

a) Scheme Guidelines;

b) PIPs being submitted by States after due approvals from SLAC;

c) Empanelment of Expert Institutions;

d) Approval of all proposals with project size above Rs.10 lakh;

e) PIP for capacity building and research;

ii) Review of the following:

a) PIP implementation;

b) Various studies;

c) Capacity Building activities of MoFPI and State agencies;

d) Trainings on skills and EDP imparted to enterprises and groups- broad review of timely trainings as per Training committee feedback;

e) Activities being undertaken for strengthening of State institutions;

f) Timely subsidy disbursal for micro enterprises and groups with Nodal Banks.

iii) Apart from the above approval and review activities, the IMEC would also undertake the following activities

a) Review and set quarterly targets;

b) Monitor inter-ministerial co-operation and convergence;

c) Oversee the overall scheme progress;

d) Oversee performance of States;

e) Any other matter relating to implementation of the Scheme.

Project Executive Committee:

A Project Executive Committee would be constituted at the operational level in the Ministry of Food Processing Industries for regular monitoring and implementation of the scheme with the following composition:

Table 2: Composition of PEC

(i)	Additional Secretary, MOFPI	Chairperson
(ii)	Additional/Joint Secretaries - Ministry/Department of Commerce, Agriculture, Rural Development, Animal Husbandry & Dairying, Fisheries, MSME, MSDE, Urban Development & Housing and NITI Aayog	Members

(iii)	AS&FA, Ministry of Food Processing Industries	Member
(iv)	Representatives of APEDA, MPEDA, NIFTEM, IIFPT, CFTRI, National Horticulture Board (NHB), FSSAI, NABARD	Members
(v)	Experts in Food Processing, Banking/Finance and Marketing	Members
(vi)	Nominees of the Partner Institutions TRIFED, NCDC, NSCFDC and SFAC	Members

The Executive Committee would meet once every month and will have the following functions:

iv) Approval of the following:

a) Examination of all the proposals submitted to IMEC for approval including PIPs of States, National institutions, State Level Technical Institutions and projects for approval above Rs 10 lakh proposed by the States;

b) Setting up of NPMU.

c) Approve projects under the scheme for items to be spent by Government of India and those with 100% central share up to a limit of Rs 10 lakh;

d) Release of 60% of the matching grant as GOI share to the individual beneficiaries;

e) IEC proposals

f) MIS related decisions;

v) Review of the following:

a) Timely subsidy disbursal for micro enterprises and groups with Nodal Banks and escalation to IMEC in case of need;

vi) Apart from the above approval and review activities, the PEC would also undertake the following activities:

a) Set monthly targets for the scheme in line with the annual targets being set by the IMEC;

b) Monitor the progress of the scheme through the portal and through effective dashboard monitoring;

c) Inter Ministries cooperation.

Committee on Capacity Building & Research:

There would be a Committee for Capacity Building and Research at the national level to oversee the training and research aspects. This Committee would be chaired by a prominent industry expert. The Committee would have following the members:-

Table 3-Composition of Training Committee at MoFPI

(i)	Industry Expert	Chairperson
(ii)	Vice Chancellor, NIFTEM / Director, IIFPT	Member
(iii)	JS, MOFPI dealing with skill training	Member
(iv)	JS, MSDE	Member
(v)	Representative of Food Sector Skill Council	Member
(vi)	Representatives of CFTRI/DFRL/relevant ICAR institutes.	Member
(vii)	Representative of M/o Rural Development	Member
(viii)	Experts in Banking/Finance and Marketing/Branding as nominated by Programme Director, MoFPI.	Members

The Committee on Capacity Building & Research would have the following functions:

1. **Approval of the following:**
   - i) Guidance for the carrying out capacity building & research activities under the Scheme.
   - ii) Proposals of Capacity Building activities of MoFPI, State and District agencies for further financial approvals from PEC/IMEC
   - iii) Calendars and syllabus for training being given by National and State Agencies for enterprises and groups
   - iv) Curriculum for handholding support modules for FUPs and DPRs for the enterprises.
2. **Review of the following:**
   - i) Trainings being provided as per approved training calendars by National, State agencies and District Resource persons.

National Programme Management Unit (NPMU): There would be a PMU housed at the National level comprising professionals engaged on contract basis. The PMU would provide all support to the Programme Division of MoFPI for carrying all the functions listed above. The specific functions of the NPMU will include the following:

- i) Prepare necessary templates, closely coordinate with, mentor and monitor State PMUs and SNAs, for timely completion of studies and PIPs;
- ii) Capacity building activities of MoFPI, State and District Agencies and placing the proposals for due approvals of the training committee and PEC;

iii) Development of the National Portal and MIS and ensuring timely flow of information in the Portal;

iv) Trainings being provided as per approved training calendars by National, State agencies and District Resource persons for further review by Training Committee;

v) Strengthening of National and State Level Technical Institutions;

vi) Timely disbursal of subsidies to enterprises through the National Portal;

vii) Appraisal of DPRs submitted by the States and other agencies to MOFPI for approval;

viii) Timely provision of seed capital support to groups;

ix) Timely submissions of Branding and Marketing plans from SNA;

x) Timely setting up of the SPMUs and District Resource Persons.

Nodal Bank: MoFPI would select a Nodal Bank for facilitation and ensuring smooth flow of subsidies from the Banks to the micro enterprises. The functions of the Nodal bank would include the following:

i) Monitoring and Liaising with Banks for target driven approvals of applications and timely disbursal of subsidies to individual micro enterprises and groups;

ii) Transfer of subsidy from the central and state governments to the bank accounts of beneficiary in the lending bank branch.

State Level Structures

At the State level, a State Level Approval Committee would oversee the implementation of the scheme and the scheme would be operated by a nominated State Nodal Agency, supported by a State PMU. The details are given below.

State level Approval Committee:

The State Level Approval Committee would be chaired by the Chief Secretary or his nominee and would have the following composition:

Table 4: SLAC Composition

(i)	Chief Secretary	Chairperson
(ii)	Finance Secretary	Member
(iii)	ACS/Pr Secretary/Secretaries of Food Processing, Agriculture, Industries, MSME, Fisheries, Animal Husbandry, Skill Development	Members
(iv)	Mission Director, SRLM	Member
(v)	Representative of State Level Technical Institution	Member

(vi)	Institutions – Representatives from key State Technical Institutions.	Members
(vii)	Representatives of NABARD, NSDC, SLBC, NCDC	Member
(viii)	Experts in Banking/Finance and Marketing/Branding as nominated by the State Government	Member
(ix)	State Nodal Officer	Member Secretary

The State Government may nominate any other member to SLAC or DLC.

The State Level Approval Committee would be responsible for approval of the following:

vii) Surveys/Studies;

viii) PIP submitted by SNA;

ix) Capacity building activities of State and District officials;

x) Training and skill development calendars for State level agencies, enterprises;

xi) Strengthening of State institutions;

xii) Subsidy proposals for groups for recommending to MOFPI;

xiii) Proposals for provision of Common Facilities, groups and marketing & branding;

xiv) Seed Capital to groups;

xv) The SLAC will have power to sanction project expenditure up to Rs. 10 lakh on various activities included in the PIP;

Apart from the above approvals, the SLAC would also undertake the following activities

xvi) Set monthly targets for the scheme in line with the overall scheme targets.

xvii) Monitor the progress of the scheme through the portal.

xviii) Ensure synergy with other relevant organizations.

xix) Ensure inspection of Units/ CFC funded under the scheme.

State Nodal Department: Each State Government should appoint a Nodal Department at the Governmental level and a State Nodal Officer to oversee the implementation of the Scheme. The selection of the Nodal Department should be undertaken keeping in view the relative strength and experience of various departments in the State involved in the food processing sector at micro & cluster levels. The State Nodal Officer should be of the rank Secretary or Director/HOD. The potential nodal departments could be Agriculture or Horticulture Department,

Food Processing Department, Industries Department, MSME Department or Rural Development Department.

State Nodal Agency: Each State should appoint a State Nodal Agency. The State Nodal Agency (SNA) could be a Directorate or a Mission or an entity of the State Government. The SNA would be the operational agency at the State level for implementing the Scheme. Role and Responsibilities of the SNA shall include:

i) Conducting various studies;

ii) Getting PIP prepared;

iii) Monitoring the training and capacity building activities undertaken by State Level Technical Institute and District Resource Persons;

iv) Carrying out strengthening of State Level Technical Institution;

v) Ensuring timely submission of Subsidy proposals by District Committees;

vi) Ensuring timely submission of plans for provision of Common Facilities;

vii) Ensuring timely submission of Seed Capital proposals of groups;

viii) Developing Branding and Marketing proposals;

ix) Monitoring the handholding support being given by District Resource Persons to enterprises for DPRs;

x) Setting up of SPMU;

xi) Monitoring and approvals for hiring of District Resource Persons;

xii) Furnishing Utilization Certificates (UCs) and regular Progress Reports to MoFPI in the prescribed formats;

xiii) IEC;

xiv) Sharing of best practices.

State Project Management Unit (SPMU):

- ✓ The State Nodal Agency (SNA) should appoint a State Project Management Unit (SPMU). The SPMU could be appointed by recruiting the staff on contract basis or on deputation or own staff of SNA. The SPMU staff should be engaged on full-time basis for the work of the Scheme. SNA may decide to appoint a private agency also as a SPMU through competitive bidding process.
- ✓ SNA would be provided 2% of the Scheme expenses as administrative expenses. The expenses of the SPMU would be borne by the SNA from 2% for administrative cost allowed under the Scheme. Details of staff of SPMU along with qualification would be as prescribed.
- ✓ SPMU would have the key responsibility of supporting the SNA in all the functions as indicated in para 9.3.4.

District Level Structures

District Level Committee: At the district level, a District Level Committee (DLC) would be constituted under the Chairmanship of District Collector. The Committee would have representation from panchayats, banks, subject experts, academia, community institutions, FPOs/SHGs, etc. The District Collector may co-opt any other person as a member of DLC. The composition of the District Level Committee would be :

Table 5: Composition of DLC

(i)	District Collector	Chairperson
(ii)	GM, DIC, District Agriculture Officer, District Horticulture Officer	Member
(iii)	Sarpanch of one GP	Member
(iv)	One Block Development Officer	Member
(v)	District Lead Bank Manager	Member
(vi)	SHG/FPO representatives	Members
(vii)	Representative of NABARD	Member
(viii)	District representative of SRLM	Member
(viii)	Any other persons nominated by Collector	Member

The DLC would be responsible for the following:

xx) Approvals of applications for loan and subsidy to individual micro enterprises;

xxi) Recommend applications for common infrastructures & groups to SNA;

xxii) Monitor handholding support being rendered to micro enterprises by District Resource Persons;

xxiii) Monitor the progress of the Scheme through the portal and through effective dashboard monitoring;

xxiv) Ensure synergy with all relevant Institutions.

Resources Persons

- At the district/regional level, Resources Persons should be appointed by SNA for providing handholding support to the beneficiaries.
- RPs should have the following qualifications:

xxv) Diploma/degree in Food Technology/ Food Engineering from reputed National/ International University/Institute

xxvi) 3-5 years' experience in providing consultancy services to food processing industries for technology upgradation, new product development, quality assurance, food safety management;

xxvii) If persons qualified in food technology are not available, persons with experience in food processing industry, banking, DPR preparation and training may be engaged.

- Handholding support should be provided by the Resource Persons to individual units and groups for preparation of DPR, taking bank loan, support for obtaining necessary registration and licences including food standards of FSSAI, Udyog Aadhar, GST etc.
- Payment to the Resource Persons would be made on the basis of each beneficiary supported by them after sanction of loan to them by the bank. Payment to each Resources Person would be @ Rs.20,000/- per bank loan sanctioned. 50% of the payment would be made after sanction of bank loan and remaining 50% after the Units takes GST &Udyog Aadhar registration, takes standard compliance of FSSAI. Implement the project and is given training.

State Nodal Department should decide on the flow& approval process of applications and support under the Scheme. They should decide the respective roles of DLC, SNA & State Level Technical Institutions for the following:-

(i) Approval level for shortlisting of individual application;

(ii) Flow of application of groups & common infrastructure within the state level;

(iii) Training & capacity building activities and decision making between DLC, SNA & State Level Technical Institutions;

(iv) This decision on the flow of applications & process for support within the state would apply irrespective of the roles of the agencies specified in the Guidelines.

Partner Institutions for Convergence

The scheme lays special focus on SC/ST, women and aspirational districts and FPOs, SHGs and producer cooperatives. The following organisations have been working in these areas:

a) TRIFED;

b) National SC Development Finance Corporation;

c) National Cooperative Development Cooperation;

d) Small Farmer Agri-Business Consortium;

e) National Rural Livelihood Mission under M/o Rural Development.

The above institutions may converge their activities by facilitating identification of units / clusters of STs, SCs, cooperatives, FPOs and SHGs respectively. They should support preparation of DPRs and proposals for funding and development of such institutions under the Scheme and feed such proposals to the State PIPs.

They should also provide handholding support to such supported units and work with the States in this endeavor. Each of the Partner Institutions would be member of the PEC.

Studies & Reports

- **State Level Upgradation Plan (SLUP):** The SNA should conduct a State Level Upgradation Plan (SLUP) which will have the following two components:

- **Base-Line Assessments**: The baseline study should focus on 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.
- **State Level Upgradation Plan:** Once decision is taken on the ODOP, detailed study 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, number of processing units, their details, etc. This study should be conducted by 31 December, 2020. The amount provided for the above study would be Rs.10.0 – 75.0 lakh to the States. The Terms of Reference (TOR) of the above studies would be as prescribed.
    - **Study of FPOs/Producer Cooperatives/ SHGs:** In parallel to the above study, SNAs in coordination with NCDC, SFAC, TRIFED, NSCFDC and SRLMs should collect data on the level of operation of SHGs, producer cooperatives, FPOs in the states.

Once the infrastructure and other facilities as envisaged in the State Level Upgradation Plan have been carried out, another study should be carried out for further course of action for ODOP in such districts. For any other studies to be conducted by the SNA, they should include the proposal for the study in Project Implementation Plan and send it for approval to MoFPI along with cost estimates.

Project Implementation Plan (PIP)

Each State should prepare a PIP for the year in the month of January of the previous year and send it to MoFPI for approval by 31st January of that year. The PIP should be placed before the Inter Ministerial Empowered Committee for approval. The State Level Approval Committee should recommend the PIP to MoFPI. MoFPI should approve the PIP by 31st March of the previous Financial year. In the year 2020-21, PIPs should be sent by the States to MoFPI for approval by 30th September 2020.

The PIP should contain the following details:-

i) Implementation arrangements for programme in the State including the agencies assigned, institutions selected etc;

ii) State Nodal Agency details along with officers assigned;

iii) Composition of SLAC/DLC;

iv) Details and plans for setting up of SPMU and manpower;

v) Details and plans for hiring of District Resource Persons;

vi) Details of State Level Technical Institution;

vii) Activities planned for the year as aligned with the scheme guidelines;

a) Details of studies planned and timelines for completion;

b) Details of trainings planned for the year with clear role matrix for the different institutions;

c) Broad targets for subsidy disbursement and number of enterprises booth groups and individuals;

d) Broad list of clusters district wise;

e) Listing of SHGs/FPOs/Cooperatives in the State, identified as potential stakeholders in the programme;

f) Abstract of Branding and Marketing plans for the products.

viii) Detailed cost estimates and budgets for all the activities for the year;

ix) Detailed flow chart of implementing the activities planned;

x) Stakeholder matrix with clear roles and responsibilities earmarked for each person.

PIP is a planning & budgeting exercise. After the approval of PIP, States should go ahead for incurring expenditure for the items subject to the delegation of powers given to the States.

State Level Approval Committee is empowered to sanction expenditure for individual items up to Rs.10 lakh and any proposal for expenditure above Rs.10 lakh should be sent to MoFPI for approval. That would include DPRs for projects with grant above Rs 10 lakh, expenditure on State Level Technical Institution that exceeds Rs 10 lakh, etc.

In case of NIFTEM and IIFPT, after approval of their PIP, the existing delegation of powers within the organization should be used for incurring expenditure up to Rs.10 lakh. Any proposal for incurring any expenditure above Rs.10 lakh should be sent to MoFPI for approval, as a specific proposal.

Disbursement of Funds

- The scheme is a centrally sponsored scheme with the following sharing of resources between the Centre and the States:

i) Centre-State share at 60:40;

ii) 90:10 sharing between center and Himalayan and North Eastern States;

iii) UTs with legislature sharing would be 60:40 between the Centre and the States;

iv) UTs without legislature 100% funds would be provided by the Central Government.

- The following components would be met 100% by the Central Government:

v) Capacity buildings & training;

vi) Administrative cost of national PMU for MoFPI;

vii) Training support in terms of audio-visual, development of print material, development of modules etc. at the national level;

viii) MIS;

ix) Development of technologies, products, etc;

x) Support to national level partner institutions;

xi) Promotional activities at the national level;

xii) Any other expenditure made directly by Govt. of India would be borne 100% by MOFPI.

- Expenditure in the first year, whether incurred by the Centre or the States would be borne 100% by the Govt. of India. This is being done because the Scheme is launched after the State budgets have been approved. Therefore, the States may be able to provide funding only after Supplementary Budgets are approved. The expenditure made in the first year would be adjusted in 60:40 ratio in the funds being transferred to the States equally in the next four years.
- The funds would be provided to the States based on the approved PIP in two installments in a year after Utilization Certificate (UC) for the installments other than the immediate previous release, have been given. There would be no such requirement of UC for the funds transferred in the year 2020-21.
- To meet administrative expenditure for PMUs, studies & training, grant of would be provided to the States in the second/third quarter of 2020-21. Subsequently, after the approval of PIP, funds would be provided for the full year 2020-21 to the States in a single installment.

Allocation for Scheduled Caste (SC)/ Scheduled Tribe (ST)/ North Eastern Region (NER)

- Specific allocations for SC/ST and NER would be made in the budget allocations under the Scheme. These funds would be allocated to the States based on population of SC/ST in the States. Such SC/ST allocations could only be utilized

for giving benefits under the Scheme to the units owned by SC/ST persons respectively. In case of Groups, such funds could be utilized only if more than 50% of the members of such groups belong to SC/ST community. In case of North Eastern States, allocations would be made under the Scheme to comply with the norms of using such funds in such States.

Credit Linkage

- The main expenditure under the Scheme is credit linked grant @35% for the for micro food processing enterprises subject to a maximum of Rs.10 lakh. Additionally, credit linked grant is being provided to groups @35% for capital investment, credit linked grant for common infrastructure @ 35%. These grants would be transferred to the lending bank after sanction of the loan by the bank.

- At the national level, a Nodal bank would be appointed for disbursement of subsidy to the banks and liaison with the banks.
- The bank sanctioning the loan would open a mirror account in the name of the beneficiary. The lending bank would report the fact of sanction of loan to the Nodal Bank at the national level. After receipt of this information, Central and State Government should respectively transfer 60% and 40% of its share of grant to the Nodal Bank. The Nodal Bank would transfer 60% of the Central share of the grant and 40% of the State share of the grant together to the concerned lending Bank branch. That Bank branch should place this amount in the mirror-bank account of the beneficiary. The lending bank should disburse sanction loan amount in accordance with normal banking practice to the beneficiary/supplier.
- 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 grant amount would be adjusted in the bank account of the beneficiary. If the account becomes NPA prior to three years from the date of disbursement of the loan, the grant amount would be adjusted by the Bank towards repayment by the beneficiary. If the grant amount is adjusted after three years against the loan amount in case of standard account, no interest would be payable by the borrower on the portion of the loan disbursed by the Bank equal to the grant amount from the date of receipt of the grant amount by the lending bank.

- Benefit of credit guarantee coverage for loans offered under this Scheme should be provided to the borrower under the Credit Guarantee Trust for Micro & Small Enterprises through the National Credit Guarantee Trustee Company under their usual terms & conditions. Interest subvention of 2% under the Interest Subvention Scheme for incremental credit to MSMEs 2018 would also be available to the borrowers on the outstanding balance.

- It should be ensured by the SNA that the applications are forwarded to the banks on a regular basis rather than forwarding a bunch of them together on a monthly or quarterly basis.

- The proposals should be forwarded to the bank branches along with basic KYC of the applicant. To minimize the processing time, applications should be forwarded to the banks along with all the requisite documents required for loan applications such as lease/ownership documents of land for setting up the unit/machinery, registration and necessary Government clearances, etc. Applications should carry complete project details and the DPR should be commensurate with the economic viability of the locality. Project cost should be a realistic figure based on a reasonable assessment of the economic viability of the project.

MIS

- The Scheme would to be monitored and the entire flow of data and approval of proposals, etc. would take place on an online system. An MIS would be developed by MoFPI for this purpose. The following information flow/approvals would take place on MIS:

    i) Proposals for PIP sent by the States and their approval including any changes by MoFPI;

    ii) Proposal of PIP by national level training institutions of their approval including any changes;

    iii) Application for loans submitted by individual micro food processing enterprises;

    iv) Uploading of DPRs and details of handholding support provided;

    v) Details of training support provided to individual Units;

    vi) Forwarding of loan proposals to the banks;

    vii) Uploading of details of sanction of loan by the banks;

    viii) Any payment made to any person or agency including groups and maintenance of accounts;

    ix) Any support provided in terms of training, hand holding to groups and individuals;

    x) A ledger should be there for each individual and group selected under the Scheme. This ledger should provide details of all the support to the individual and group, details their economic activities, disbursement of loans etc;

    xi) All payments made by SNA/ MoFPI under the Scheme to any entity should be entered into MIS. All activities undertaken under the Scheme should be entered into the MIS;

xii) MIS would be developed by MoFPI. All expenditure for development, maintenance and monitoring would be met by MoFPI under the Scheme.

Empanelment of Expert Institutions

A large number of institutions, both in Government and private exist with expertise in marketing, research, product development, packaging, branding, training, handholding support, etc. For each of these activities, MoFPI would empanel institutions at the National level, whose services could be utilized by the States. The empanelment would be carried out by a transparent process for evaluation of expertise in the field. Award of work to these empaneled institutions by the States should be done after inviting financial proposals for the task involved by them.

Convergence Framework

Food Processing Enterprises being supported under the Scheme would be eligible for benefits under the following Government Schemes:

i) National Rural Livelihood Mission – providing seed capital, training, handholding support and interest subvention to SHGs;

ii) Start-up Village Entrepreneurship Programme (SVEP) –It is a Centrally Sponsored Scheme, a part of NRLM, provides capital and technical support to rural start-ups through training, handholding and support through Community Enterprises Fund (CEF) as a loan up to Rs.1 lakh for individual entrepreneur and Rs.5 lakh for group entrepreneurs at 12% interest;

iii) Interest Subvention Scheme for incremental credit to MSMEs 2018 – 2% interest subvention on outstanding balance;

iv) Credit Guarantee Trust Fund for Micro & Small Enterprises (CGTMSE) for collateral free loan up to Rs 2 crore;

v) PM MUDRA Yojana for loan up to Rs.10 lakh;

vi) A Scheme for Promotion of Innovation, Rural Industry and Entrepreneurship (ASPIRE);

vii) Scheme for Fund for Regeneration of Rural Industry (SFURTI);

viii) Public Procurement Policy for MSEs;

ix) Benefits available under various other Schemes of MoFPI such as Backward & Forward Linkages, Agricultural Production Cluster, Cold Chain etc. would be used to provide support to clusters/groups.

x) Support from PMKVY and NRLM for skill training for SHGs, if falling within the guidelines would be taken. For shorter duration on site trainings, support would be provided from NRLM and the PM FME scheme, tailor-made for such purposes.

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MINISTRY OF FOOD PROCESSING INDUSTRIES
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SHARAD

Chapter 1
Status and Scope of food grain processing

Cereals and grain legumes form staple food for the Indian population, contributing as much as 75% of dietary carbohydrates and also a considerable proportion of protein and other essential nutrients. Food grains provide nutrition to the people indirectly also as livestock feed constituents for producing meat, milk and eggs. With the production of more than 290 million tons of grains (more than 10% share in the world production), Indian grain processing sector is a gigantic industry. It includes all the post-harvest operations including pre-milling operations like drying & parboiling, milling of paddy, wheat, coarse grains, millets and legumes to convert them to ready-to-cook , ready-to-use as well as ready-to-eat products. India stands first, second and fourth in the production of pulses, rice and wheat respectively with respect to the world food grain production and also forms the largest consumer of rice and pulses.

Food grains are never harvested in ready-to-eat form and many of them contain non-edible constituents and invariably require some kind of processing (primary, secondary and tertiary) which essentially aims at transforming them to appropriate consumable forms. In view of this, grain processing is the most important activity in the value chain aimed at improving shelf-life, acceptability, nutrition and safety of products. Processing also focuses on minimizing qualitative and quantitative deterioration or loss of edible matter and nutrients by the application of appropriate methods and equipment/ machinery. It also aims at utilizing by-products and further downstream processing to prepare convenience and value-added products. Thus, grain processing is a multi-disciplinary mission addressing issues and opportunities related to production, storage, food quality, value addition, by-product utilization etc. The term grain processing implies distinctly different meanings for the different major food grains such as rice, wheat, maize, barley and grain legumes, specifically with respect to primary processing.

However, the secondary and tertiary processing is more or less common for all. Accordingly, the scenario of processing of some of the major grains is briefly dealt in the following lines:

Rice: Rice, harvested in the form of paddy (rough rice) is milled either in its native state or after parboiling. About 50% of the paddy produced in the country is parboiled. Even though, parboiling is an age-old process, the hot soaking-steaming method developed at CFTRI, Mysore in early sixties and its variants are the most predominant processing methods adapted by the industry to produce high quality parboiled rice. Most of the parboiling units have LSU type mechanical dryers. Rice milling essentially is the process of obtaining table rice by removing husk and bran (partially or completely) enveloping it. Improvements aimed at higher recovery of head rice and minimization of brokens has been a continuous endeavour of this sector. More than 1,35,000 milling units spread across the country employ various types of equipment and adapt different levels of technologies. Around 65% of nearly 100 plus million tons of paddy available for milling is converted to rice in modern rice mills which include some of the ultra- modern mills having very large milling capacity while the rest is milled in small capacity traditional hullers. Pre-cleaning, dehusking in rubber roll sheller, paddy separation and multi-stage debranning (using abrasive or combination of abrasive & friction type polishers/whiteners) is the most practical method adapted by the modern rice mills. The number of high capacity, ultra-modern integrated mills are increasing and small as well as tiny units are finding it difficult to survive. Automation, process control as well as cogeneration are becoming the key issues in rice mills. Most of the modern rice mills have also incorporated silky polishers and colour sorters to provide the consumer highly appealing product. However, till date, no pre-milling sorting mechanism has been developed for eliminating fissured paddy susceptible for milling breakage. Utilization of rice bran though has been realized with over 5 lakh tons of edible oil produced, downstream processing like production of oryzanol and other nutraceuticals, purification of bran for food uses mainly as a source of protein and dietary fibre is yet to gain prominence in the country. Better utilization of paddy husk apart from its widespread use as a fuel for combustion is not achieved yet despite attempts made to produce

electronic grade silica, furfural and other value added chemical products. Nearly 10% of paddy produced in the country is used for the production of products like flakes, popped as well as puffed rice. These nutritious, convenience food products are still being produced by following traditional practices. The advantages of pre-treating and enriching rice to improve its functionality, nutritional and nutraceutical qualities have been recognized. This high priority aspect needs concerted R&D efforts. Since, rice carbohydrates are rapidly digestible compared many other cereals, regular milled rice consumers are prone to hyperglycemia. Processing rice to slow down its carbohydrate digestibility may hence have global benefits with respect to controlling the ever-increasing incidence of diabetes and obesity. There is an urgent need to upgrade the technology to produce globally acceptable products of improved quality, with an emphasis on mechanization of the various unit operations adapting HACCP and environmental safety aspects, with an edge on retaining the health beneficial constituents. In this direction, GABA rice, nutrient rich synthetic rice, which can be easily adapted at household level needs popularization.

Wheat: The primary processing for wheat is flour milling to produce size graded products such as whole meal, refined flour, semolina and grits. This is mostly carried out in about 1000 large flour mills besides over 3 lakh small units (*chakkis*) operating in the unorganized sector. More than 80% of the wheat harvested in India is used for making the unleavened bread – *chapati.* For *chapati,* wheat is generally pulverized in chakkis. The primary products of roller milling viz., maida and semolina are mostly used for bakery (bread, biscuit, pastries, cakes, buns, rusk etc.) or pasta (vermicelli, noodles, macaroni) products. The number of bakery and noodle producing units are increasing steadily in the country while bread and biscuits constitute the largest segment of consumer foods. About 35% of these are produced in the organized sector whereas the unorganised sector contributes for the rest. Although grain hardness is the most important quality criterion for procurement wheat worldwide, this is not strictly followed in the country and consequently the industry is constrained by this grain grading, classification and procurement system. Recently, several multinationals have entered the wheat milling sector and are producing atta as well as several traditional wheat products. Preparation of whole wheat as well as composite flour-based bakery products

and mechanization of traditional non-bakery wheat products will have greater opportunity. Since, gluten allergy is rampant worldwide, efforts are also required to get `gluten-free'. Wheat germ and bran the by-products of roller flour milling system are valuable sources of nutraceuticals and concerted effort to utilize them in health foods deserves attention.

Pulses: Unlike milling of cereals, processing of pulses is unique and indigenous to India which is solely aimed at producing dhal (dehusked split pulse). Dhal milling industry is the third largest in the grain processing sector milling about 75% of the 15 million tons of pulses produced in the country and has approximately 11,000 mechanized mills in the organized segment. Dhal milling basically aims at removal of seed coat or the hulls and splitting the legume cotyledons. Seed coat is loosened by wet and dry methods of pretreatments, involving steeping the pulses in water for a few minutes to a few hours, sun drying, tempering for 1-5 days and milling or just scratching or pitting by abrasion, smearing with oil and water, tempering for 1-5 days and milling, respectively. Decorticated pulses are generally given mild polish to improve the consumer appeal. To improve the yield of 'quality dhal', newer technologies and innovative milling machines are being developed. The hand/ electrically operated mini dhal mill, versatile mini dhal mill, versatile dhal mill and modern dhal mill of CFTRI and also mills developed by some other organizations are noteworthy in this direction. Pulses are also processed to produce puffed grams and pulse flours and these are still labour intensive processes. Automation and electronic process control are virtually not heard of in this sector even though a few progressive entrepreneurs are trying to modernize the pulse milling units. With the production of pulses stagnating in the last three decades, there is an urgent need for increasing the agricultural production, process yields and utilization of lesser known/ under-utilized pulses. There is also a need for improving the performance of traditional mills, their operating conditions and development of modern processing machinery to minimize the loss of edible matter so that the pulse availability could be improved to some extent. Pulses are poor man's meat in India and form the major source of protein for the majority of the Indians. Hence, methods to upgrade the nutritional quality, reduction in anti-nutritional factors

besides enhancing their availability including identifying suitable food uses for the milling by products also deserve greater attention.

Coarse grains: Maize, sorghum, millets, barley, oats and the pseudo cereals are classified as coarse cereals and account for about 20 per cent of total cereal production in the country. Maize is used both as food, feed and a raw material for the production of starch and corn oil. For food and feed applications dry milling is followed whereas for producing starch, wet milling is adapted. Corn grits are largely used for breakfast cereals (corn flakes) or in the brewery and also for the production of alcohol. Efforts to use maize cob as a source of fibre and organic chemicals are also receiving attention. Sorghum is generally converted to flour for tradition foods but the industrial utilization of sorghum is almost unexplored. Millets and other coarse cereals are gaining recognition as nutria-cereals and their status in the country is improving. Finger millet has good malting qualities and its malt finds extensive use in foods, where as barley, oats, buck wheat, grain amaranthus etc have varied regional food uses. However, barley is largely utilized for malting and brewing as well as for *sattu* preparation but oats is mainly processed for porridge. There is a growing demand for oat based products in the country because of its health benefits. Muesli, the ready-to-eat breakfast cereal which invariably consisting oats as one of the ingredients is gaining firm base in the country. Details of grain production, processing and avenues for diversification are highlighted in Table 1.

There are a large number of indigenous machinery manufacturers catering to the needs of rice, wheat, pulses and coarse grain milling and the baking industry. Many of the units have engineered production of process machinery quite successfully. With many imported technologies available off-the shelf, processors are finding it difficult to choose the right one for their specific requirements. However, most of the developments have taken place for the processing of major cereals, even milling machinery are not available for small millets and this needs to be attended to.

Table 1. Food grain production, processing and products in the country

Commodity	Production (million tonne)	Important Processing methods	Main products	Opportunity for diversification
Rice	120	Milling, Flaking, Puffing, Popping	Milled rice, flakes, murmura, popped rice, noodles	Extruded products, bran enriched health foods, nutraceuticals, GABA rice, non-glutinous foods
Wheat	105	Milling, Baking, Noodles, Popping	Atta, maida, soji, noodles, dhalia, bread, biscuits, cakes	Composite flours, whole wheat, processed ready-to-eat foods, nutritious foods
Coarse cereals	45	Milling, Malting, Starch isolation, Flakes, Feed	Roti flour, semolina, brewers grits, cereal flakes, malt	Health foods, non gluten consumer products
Pulses	23	Milling, Puffing, Grinding	Dhal, pearled legumes, puffed gram, flour from expanded legume (besan)	By-product utilization, nutraceuticals, low-fat crisp products

Changing consumer market scenario, increased purchasing power, burgeoning middle class population, increasing number of women work force, drifting lifestyles from traditional values & consumption patterns, presence of international players in the market, liberalization of imports proliferation of visual media and health consciousness are altering the landscape of the grain processing industry in the country. This also has provided opportunities in terms of nutrition retention and enhancement, development of whole grain as well as, multi-grain products, organic foods, genetically modified foods, improvement and re-positioning of the traditional foods to reach the global market,

application of newer methods of production like extrusion cooking and nano-technology, etc. Industry is trying to align with the everchanging newer market orders. Grain processing sector is facing challenges on the ecological, economic and societal fronts apart from the stresses of energy deficits, reduced profit margins and competition. It still has the challenge of saving every single grain, adding value to every bit of it, not simply feeding the millions but providing them with quality food at affordable price and still deriving monetary profits for its survival and growth.

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Chapter-2
Equipment and specifications of machineries grain processing

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BACKGROUND

- Wheatis staple food for majority of population
- Annual Wheat Production: 750 million tonnes
- Consumed mostly in the form of chapatti made from atta

WHEAT: Introduction and Quality Characteristics

Wheat Classification

- Genus: Triticum
- Common Species:

  - *Triticum monococcum* (diploid)

  - *Triticum turgidum* (tetraploid)

  - *Triticum aestivum* (hexaploid)

- Variety: Processing ability- milling & product making quality

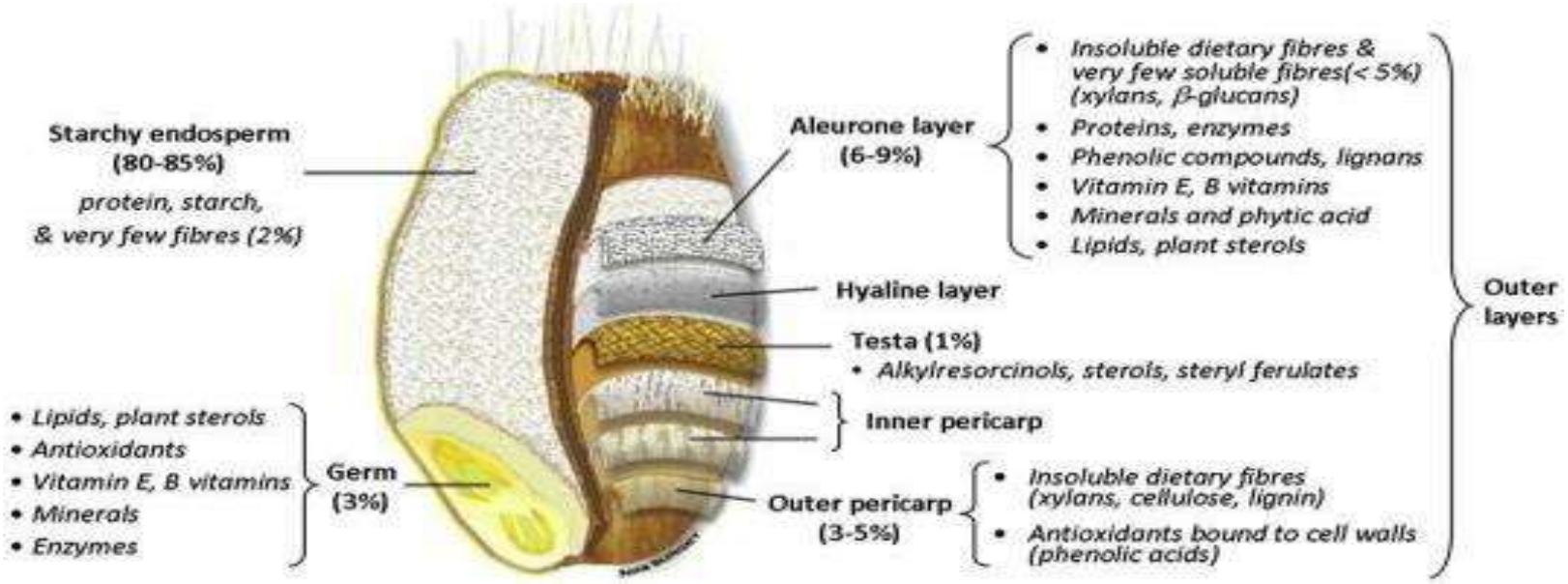
Table 1.1 Product specific wheat varieties developed in India

Wheat based Product	Variety
Bread	WH 1021, HD 2285, PBW 396, HD 277, HD 2932, GW 120, GW 190, Raj 4083, MACS 6222, NIAW 34
Chapati	LOK 1, C 306, Raj 3765, HD 2864, PBW 175, K8027, MACS 6145, UP 262, Sujata, HD 2833, Sharbati, MP 3336
Biscuit	HS 490
Pasta	PDW 233, HI 8627, HD 4672, MACS 2846, NP 200, HI8663

(Source: Gupta et al., 2014)

MORPHOLOGY & COMPOSITION

Fig 1.1 Morphology of wheat kernel



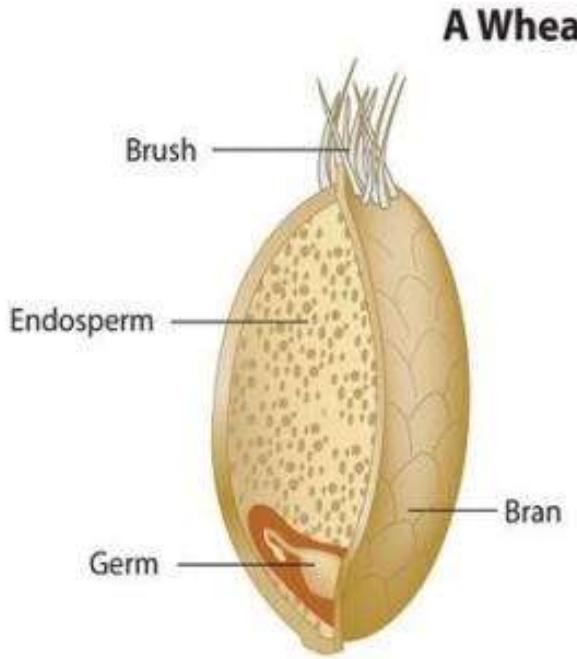
(Source:Brouns et al., 2013)

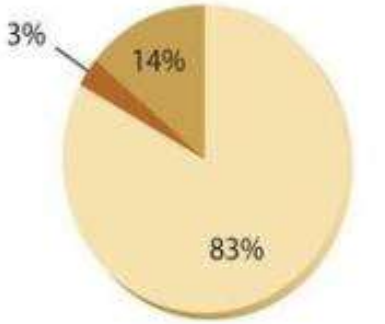
Endosperm (83%)
-energy for plant growth
-carbohydrates,protein

Bran (14%)
-protects seed
-fiber, B-vitamins,minerals

Germ (3%)
-Nourishes seed
-future wheat plant
- antioxidants,Vit. E,B-vit.

MORPHOLOGY & COMPOSITION





Composition by weight

	Carb/g	*Protein/g*	*Fat/g*	*Fiber/g*	*Iron (% daily req.)*	*Others*
Bran	63	16	3	43	59	vitamin Bs
Endosperm	79	7	0	4	7	
Germ	52	23	10	14	35	vitamin Bs omega-3/6 lipids

Nutritional value (per 100g)

CULTIVATION & PRODUCTION

Table 1.2 Wheat growing Zones of India

Wheat growing Zone	State or Area	Approximate area (million hectares)
Northern Hills Zone	Western Himalayan regions of Jammu & Kashmir (except Jammu & Kathua district); Himachal Pradesh (except Una & Paonta Valley); Uttaranchal (except Tarai area); Sikkim and hills of West Bengal & hills of North Eastern States	0.8
North Western Plains Zone	Punjab, Haryana, Rajasthan (except Kota and Udaipur divisions), Delhi, Western Uttar Pradesh (excluding Jhansi division), parts of Jammu & Kashmir (Jammu and Kathua district) and parts of Himachal Pradesh (Una district and Paonta valley) and Uttaranchal (Tarai region)	9.5
North Eastern Plains Zone	Eastern Uttar Pradesh, Jharkhand, Bihar, West Bengal, Assam, Orissa, and plains of North Eastern states	9.5
Central Zone	M.P., Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, and Jhansi division of UP	5.0
Peninsular Zone	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu	2.0
Southern Hills Zone	Hilly areas of TN and Kerala consisting Nilgiri and Palni hills of southeren plateau	0.2

(Source: Directorate of Wheat Research, Kernal, India)

CULTIVATION & PRODUCTION

- About 91% of the Indian wheat is produced in six states viz., Uttar Pradesh(34%), Punjab(22%), Haryana(13%), Madhya Pradesh(10%), Rajasthan(9%) and Bihar(6%)

- Wheat productivity in India is 3.1 tons/hectare

- Punjab (4.3t/ha) and Haryana (4t/ha) have the highest productivity than other wheat producing states

- Contribution of Uttar Pradesh and Madhya Pradesh is due to relatively large area (about 50% of total area) sown to wheat

CULTIVATION & PRODUCTION

Table 1.3 Major wheat producing countries

	Area harvested (Million Hectares)	**Production (MMT)**
	24.0	126.21
India	30.4	95.85
Russian Federation	23.9	59.71
USA	18.7	55.15
France	5.3	38.95
Canada	9.4	29.28
Germany	3.2	27.27
Pakistan	9.2	25.98
Australia	12.6	25.30
Ukraine	6.0	24.11
WORLD	**220.4**	**729.01**

(Source: FAOSTAT)

- Globally wheat is grown in 122 countries producing nearly 730 million metric tons
- India is 2nd largest producer of wheat and is maintaining the position from last eight years
- India accounts for 12.05% of the total world wheat production, which is next to China accounting 18.41%

PROCESSING

Table 1.4 Wheat quality requirements for industrial processing of wheat products

	Grain Texture	Protein content (%)	Gluten strength
***T. aestivum* wheat**			
1. Bread	Hard	>13	Strong, extensible
2. Biscuit/ cake	Soft	8-10	Weak, extensible
3. Chapati	Hard	10-13	Medium, extensible
***T. durum* wheat**			
1. Pasta products	Hard	>13	Strong

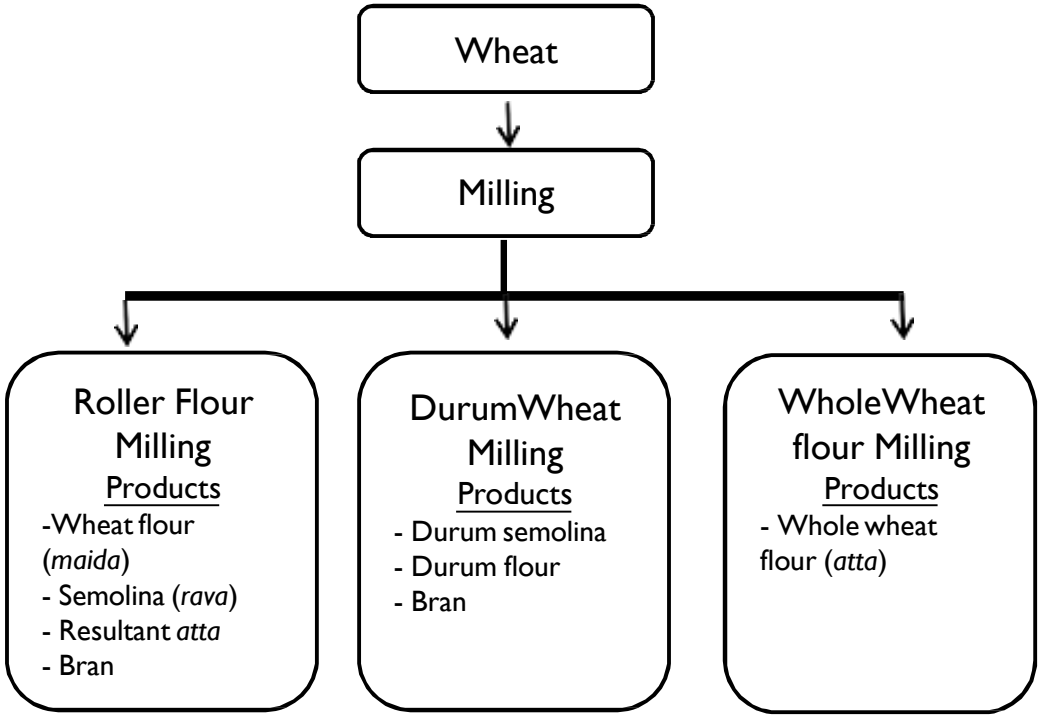


Fig 1.2 Different wheat milling methods and the products produced

UTILIZATION

Table 1.5 Food applications of popular wheat milled products

Wheat Milled Product	Product	Description
Wheat flour		
	Bread	Yeast leavened baked product from hard wheat flour
	Biscuit	Soft wheat flour baked product
	Cake	Soft wheat flour baked product
	Buns	Yeast leavened baked product from hard wheat flour
	South Indian Parotta	Flat bread with distinct layers
	Naan	Tandoor baked Flat bread
	Tortilla	Crisp flat unleavened bread
	Pizza	Thin bread with toppings
Non durum Semolina		
	Upma	Breakfast item with added spices
	Halwa	Sweet breakfast item
	Noodles	Extruded product
Resultant *atta*		
	Tandoori roti	Flat unleavened bread made on *tandoor* in local *dhabas*
Whole wheat flour		
	Chapati	Flat unleavened bread
	Parathas	Folded dough flat bread
	Puri	Deep fat fried
Durum semolina		
	Pasta	Extruded dough
Couscous	Crushed steamed semolina	

(Source: Boelen, 1989; Faridi and Faubion, 1995; Parimala and Sudha, 2015)

Physical Criteria

- Test weight
- Kernel hardness
- Structural analysis of wheat grain
- Color
- Moisture

Physical Criteria

- **Test weight**

Bulk density measure; weight of a specific volume of grain

- Provides potential flour yield

1000 Kernel weight

- Hard wheat 31 – 40 g per 1000 kernels

Soft wheat 20 – 30 g per 1000 kernels

Grain Counter

Hectolitre weight Equipment

Physical Criteria

- Kernel hardness

Hardness value (Kg/grain)	Wheat quality
> 15	Hard
< 15	Soft

Physical Criteria

- Structural analysis of wheat grain

Effect of light scattering

Compactness of starch and protein matrix

- Vitreous kernel (bright and translucent)
  - Hard wheat

Mealy Kernel (opaque and dark)
  - Soft wheat

Piebald Kernel (partly vitreous and partly mealy)
  - Medium hard wheat

Physical Criteria

- Color

Depends on colur of the bran

- Red wheat

  - North and South America, Europe and parts of Asia

- White wheat

  - Australia, India, Pakistan, Pacific Coast regions of USA

Colour Measuring Equipment

Physical Criteria

- Moisture content has inverse relationship with test weight
- Maximum permissible limits 14.0%
- Economical reason

WHEAT GRADING

- Grading permits the collection of grain of like kind and quality
- Facilitate marketing and handling
- Links farmer to agent, agent to processor and processor to end-user

Benefits of Wheat Grading

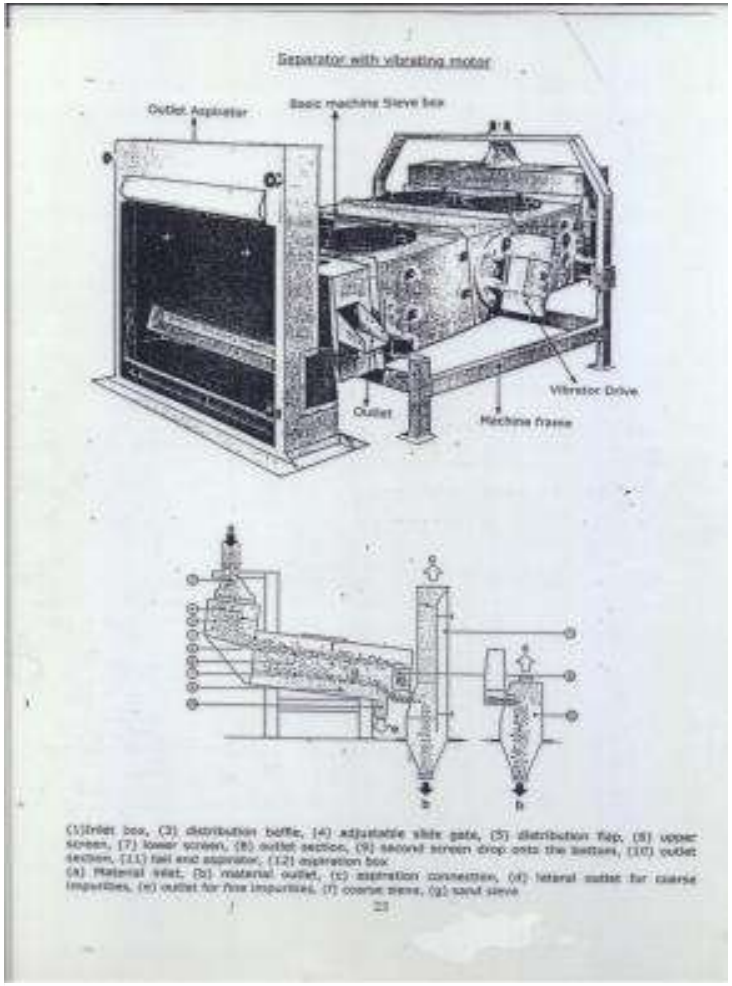
- Low expenditure in transport and storage
- Knowledge of prevailing price, and right
- Easy financial assistance, and future trading
- Widens the market for farm products
- Consumers get wide choice of quality at a reasonable price
- Promotes competitive marketing

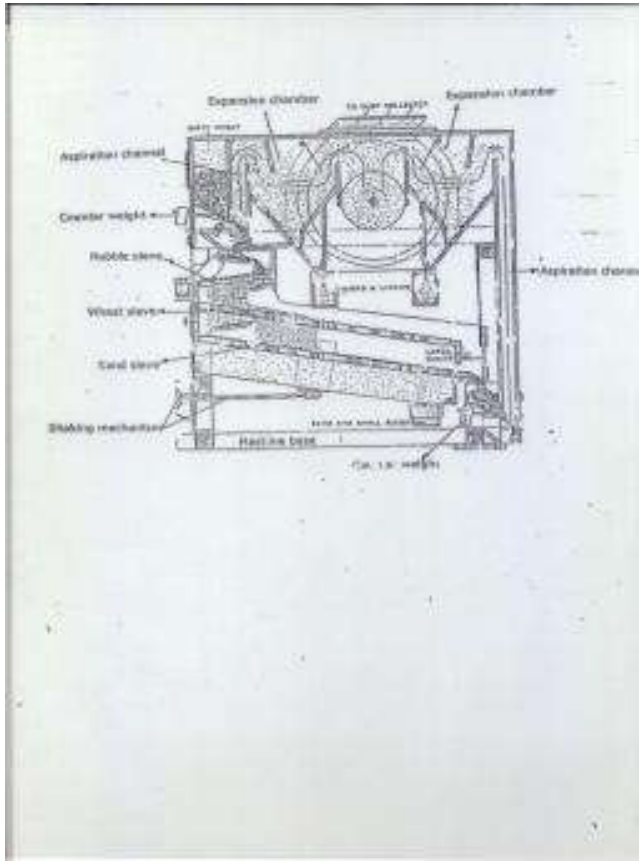
Factors for Wheat Grading

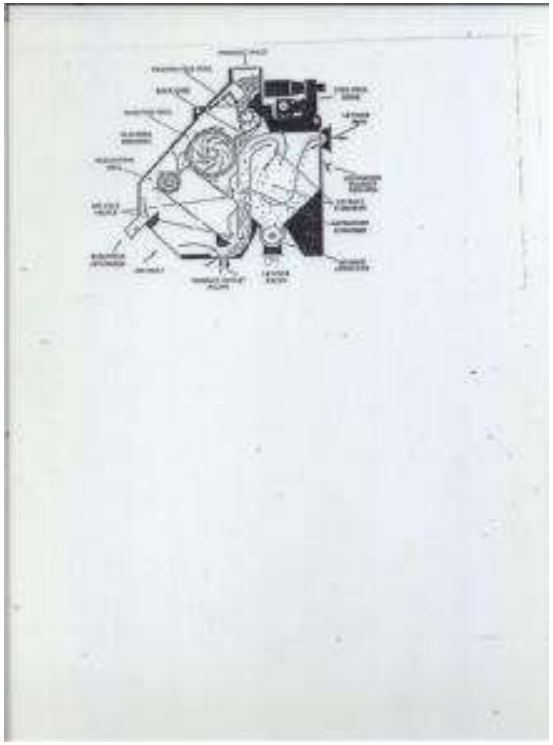
- Test weight
- Varietal purity
- Virtuousness
- Soundness
- Maximum limits of foreign materials
- Dockage
- Moisture content
- Protein content

Wheat cleaning: Machinery and Operations

Size Separation







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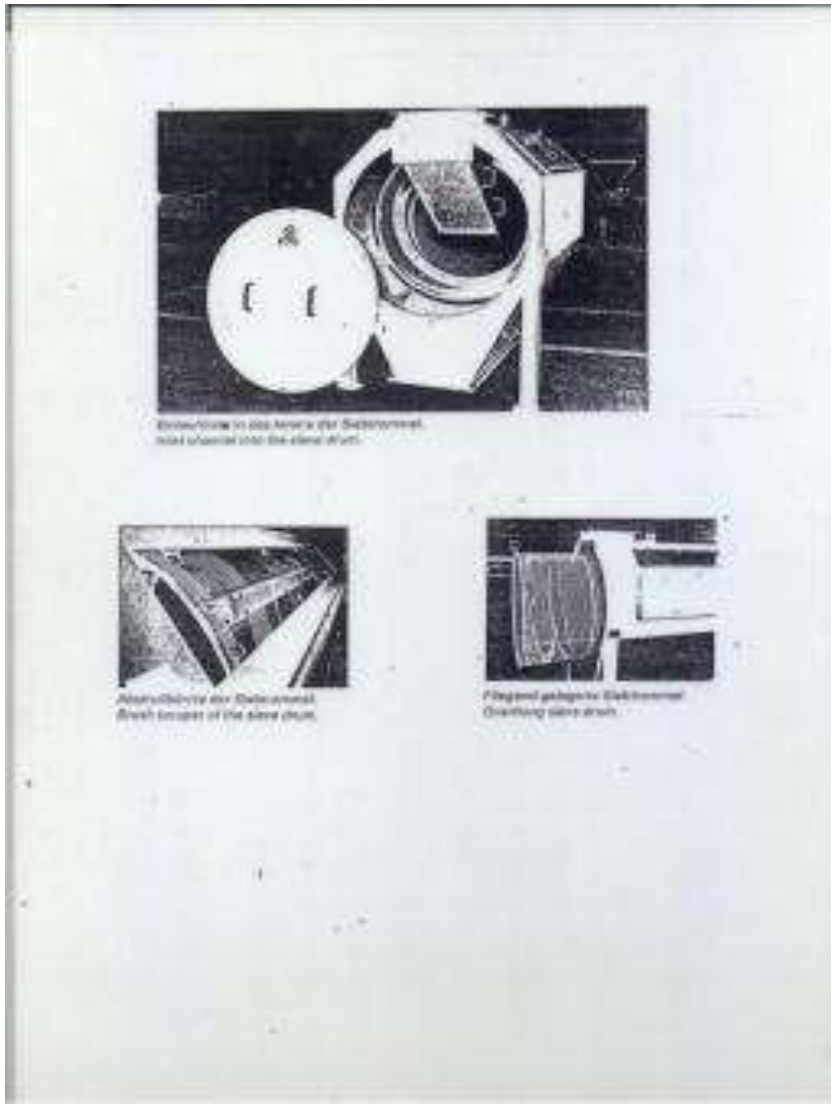
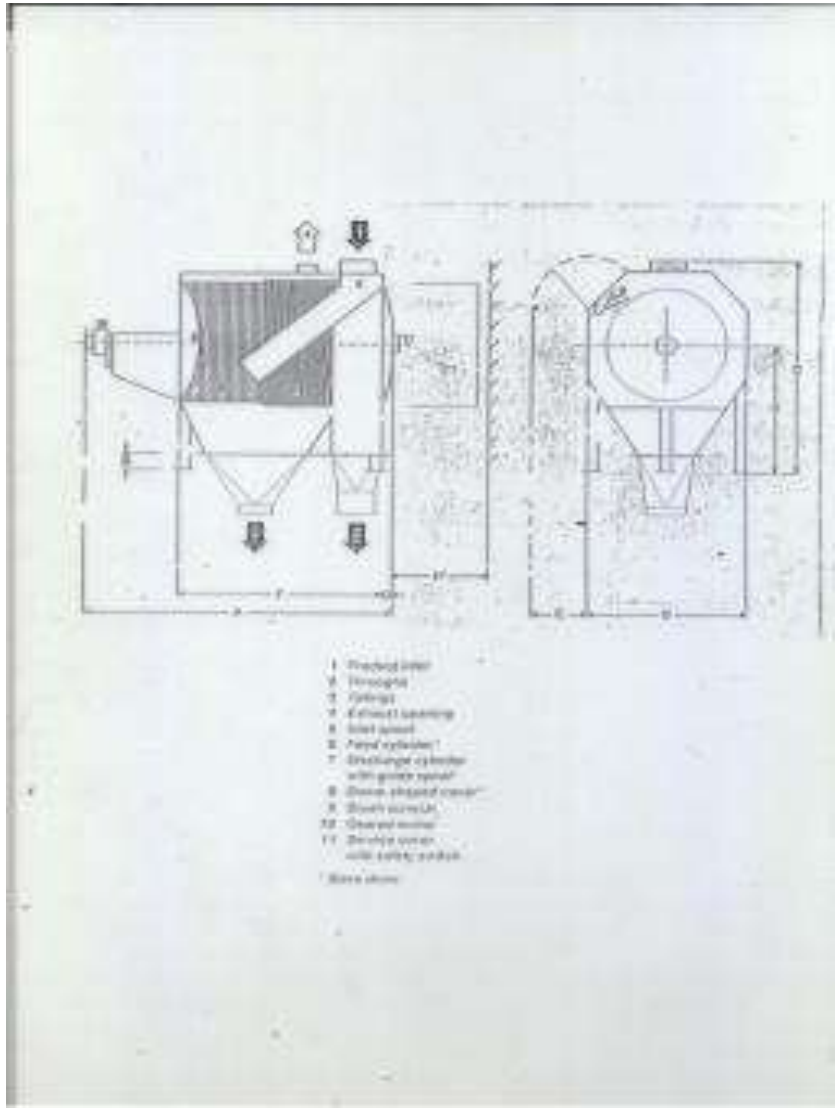




Shape Separation

Fig: Disc Seperator

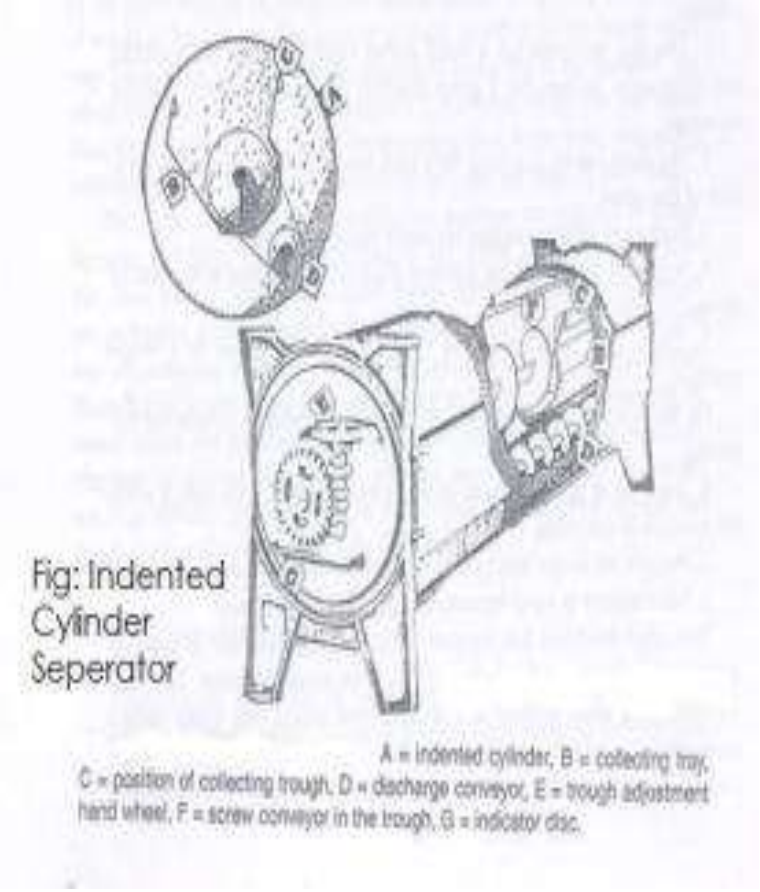


Fig: Indented Cylinder Seperator

A = indented cylinder, B = collecting tray, C = position of collecting trough, D = discharge conveyor, E = trough adjustment hand wheel, F = screw conveyor in the trough, G = indicator disc.

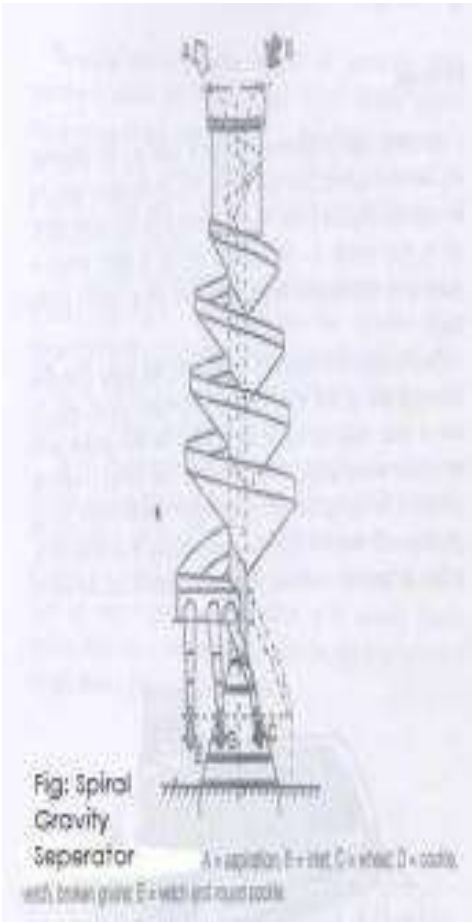
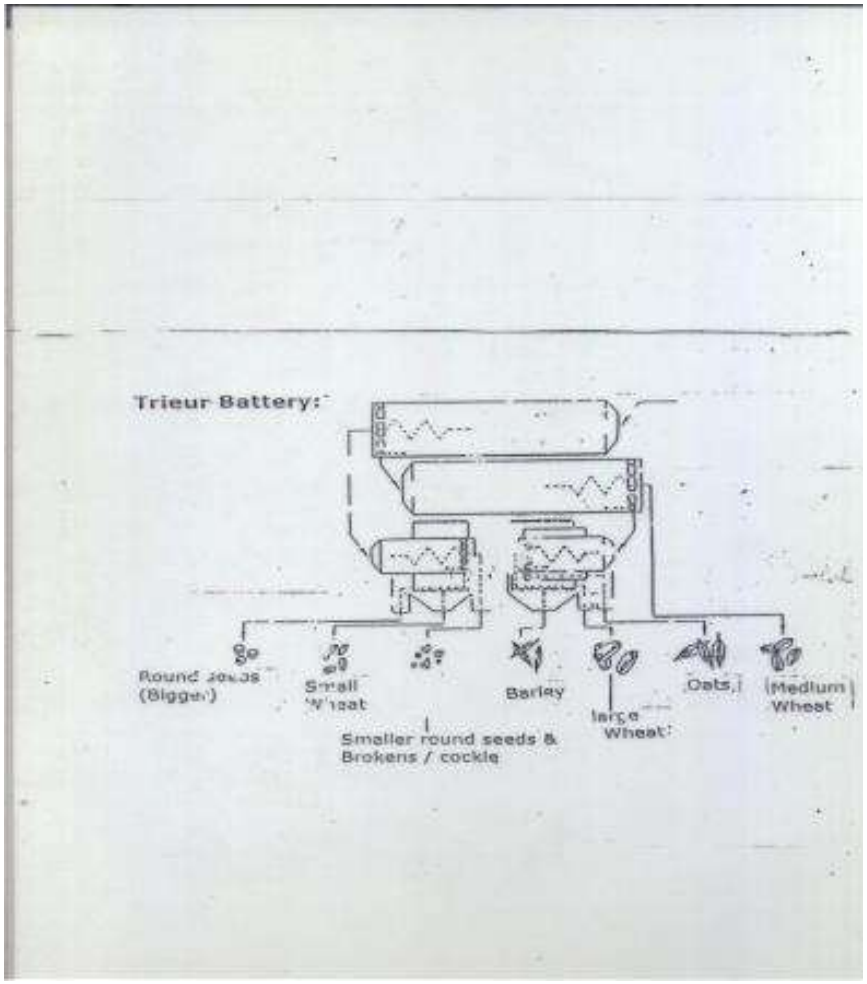
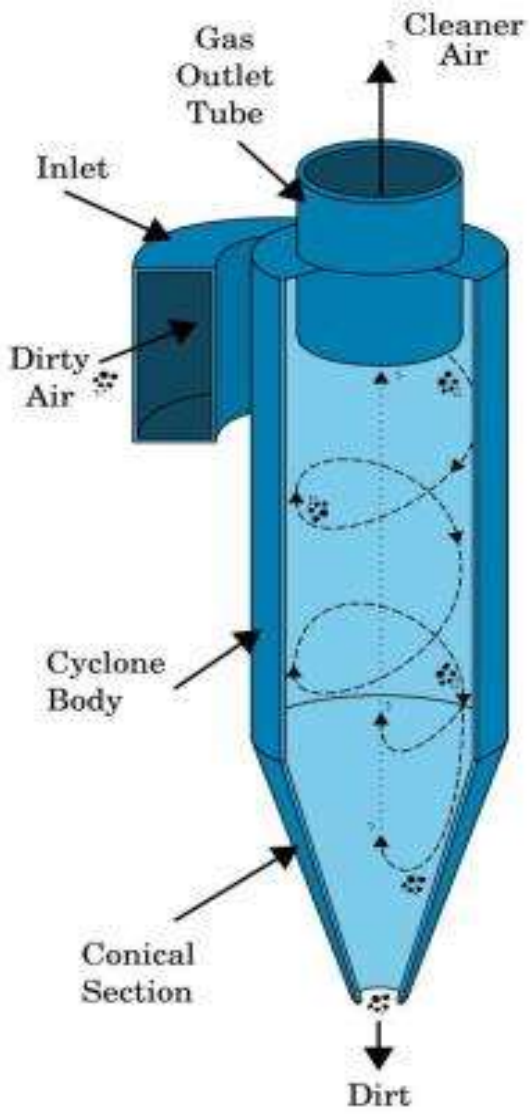


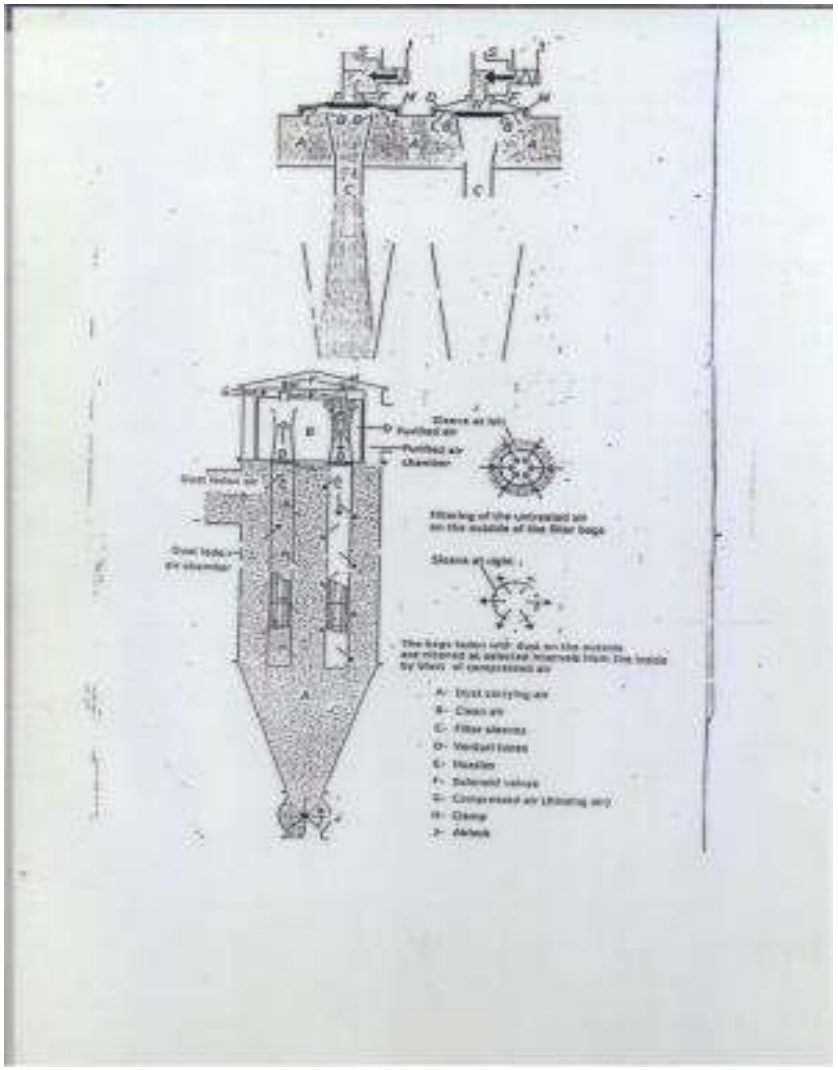
Fig: Spiral Gravity Seperator

Shape Separation



Air Cleaning Machinery



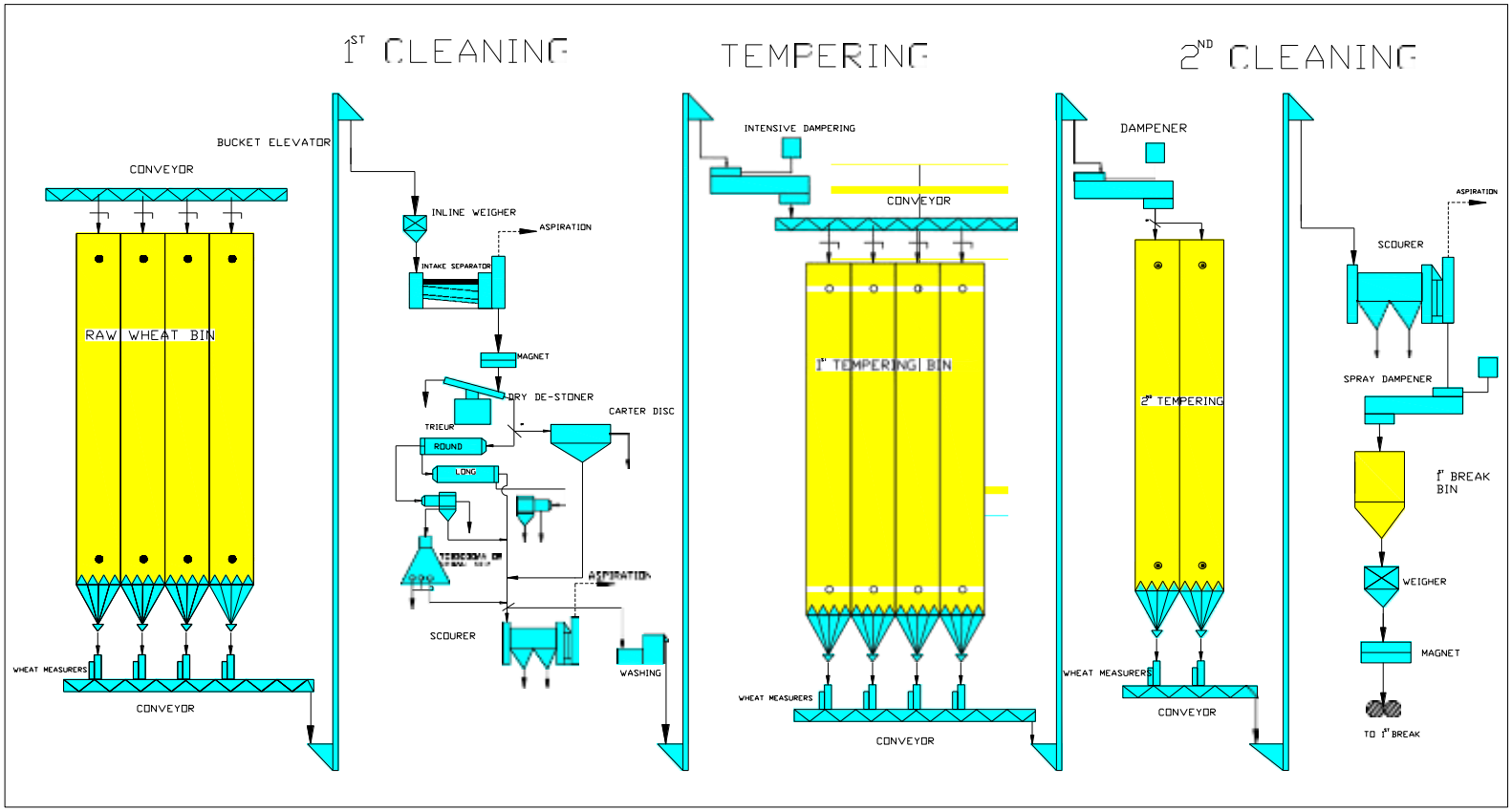


Cleaning Operations

Cleaning Operations are divided in:

- Pre Cleaning
- First Cleaning
- Second Cleaning

Cleaning Flow Sheet



WHEAT BLENDING

- Wheat blending is a vital part of the milling process that enables millers to deliver consistent quality products to their customers.
- Blending in milling is defined as proportioning together products — in this case wheat — of different characteristics with a particular final flour specification in mind.
- Mixing is the activity of homogenizing blends to ensure consistency without variation.
- Both processes are important for the greatest effect.

Reasons for blending wheat in milling process can be categorized into three areas:

- To deliver a consistent product
- To minimize raw material cost
- To develop a unique product
- Adjustment of the protein content of the final product
- Adjustment of price of wheat mixture
- Production of appropriate flour quality to the end users

WHEAT CONDITIONING

Factors influencing conditioning:

- Wheat hardness
- Raw wheat moisture
- Protein content
- Ambient Temperature
- Wheat Temperature
- Final moisture required

The equation used to add the water in lit/hr is:

$$\frac{M2-M1}{100-M2} \times \text{Flow rate in kg/hr}$$

Where M2 = Final moisture %

M1 = Raw wheat moisture %

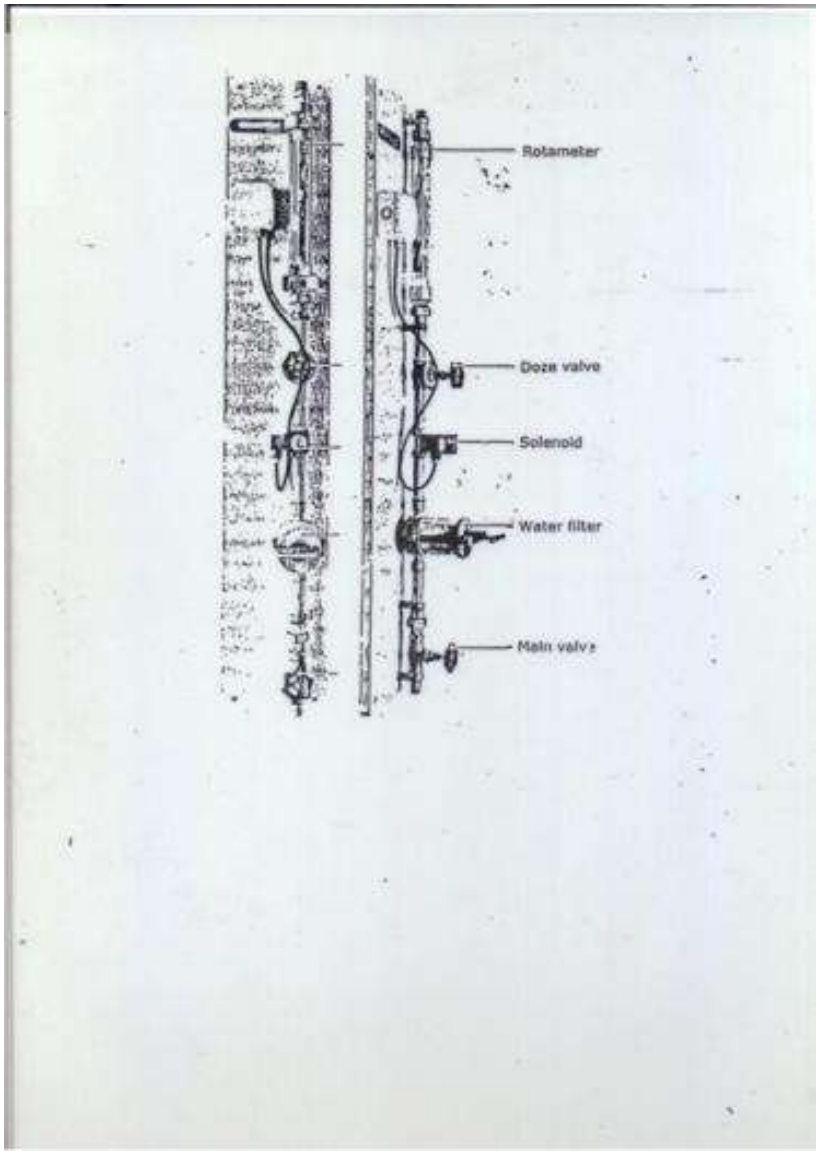
WHEAT CONDITIONING

Equipment used for water addition:

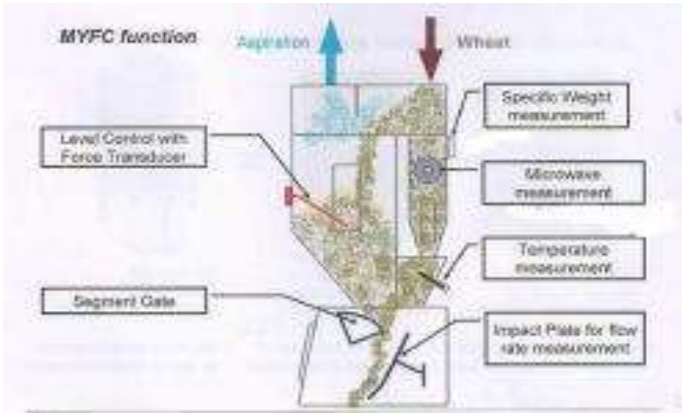
-Tap

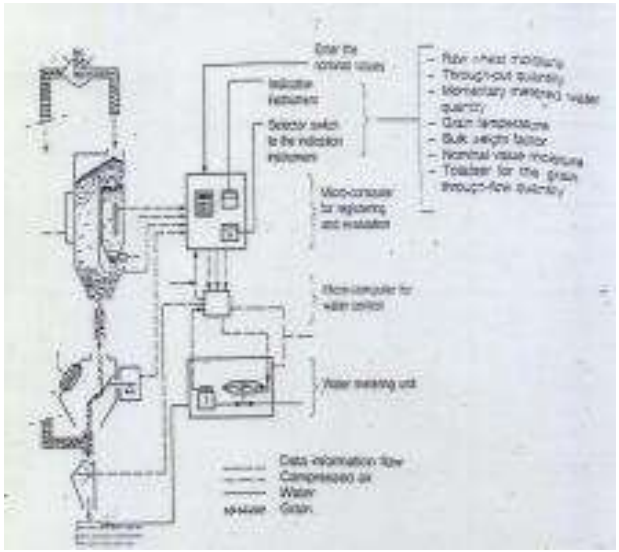
-Rotameter

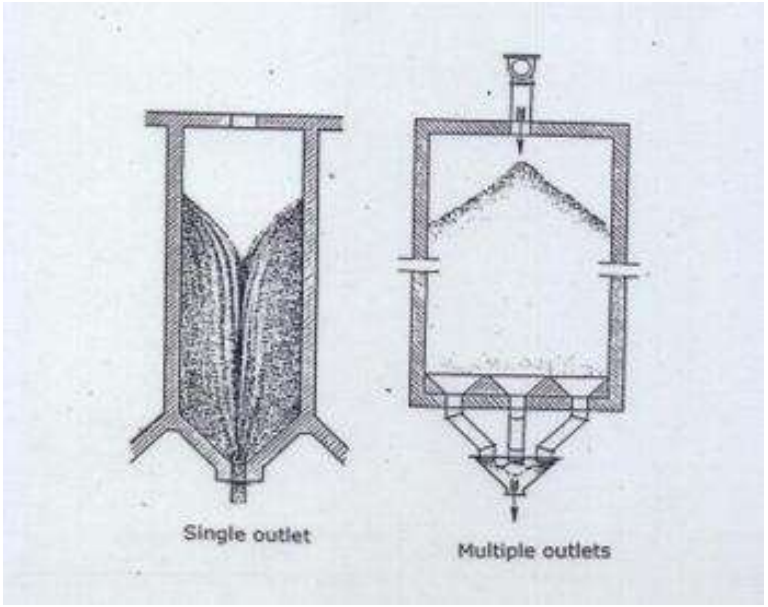
- Automatic Water addition system



WHEAT CONDITIONING



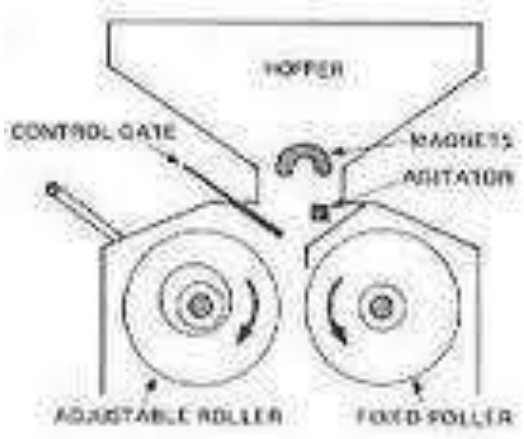




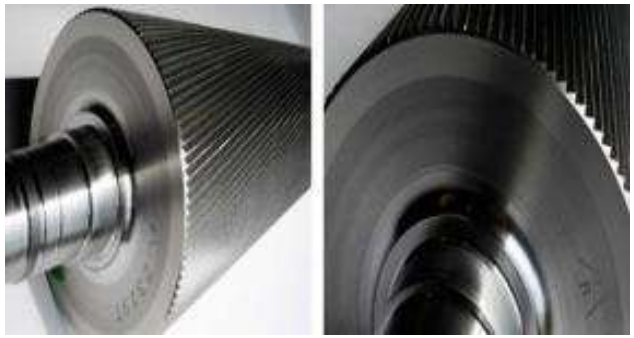
Flour Milling Process

Wheat Milling: Roller Flour Process

- Principle: Gradual Scraping and Sifting using pair of chilled cast iron rolls and sifters



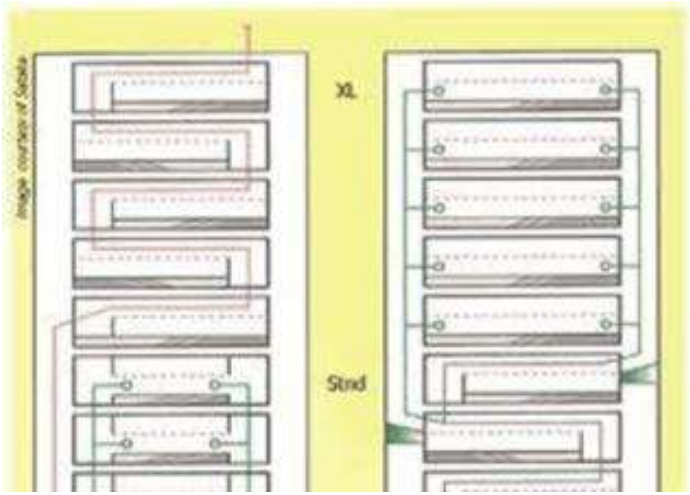
Break System



- To cut open the grain
- To scrape the endosperm
- To produce maximum clean semolina

Sifting Process

Ground stock passed through series of sieves for size separation in form of overtails and throughs



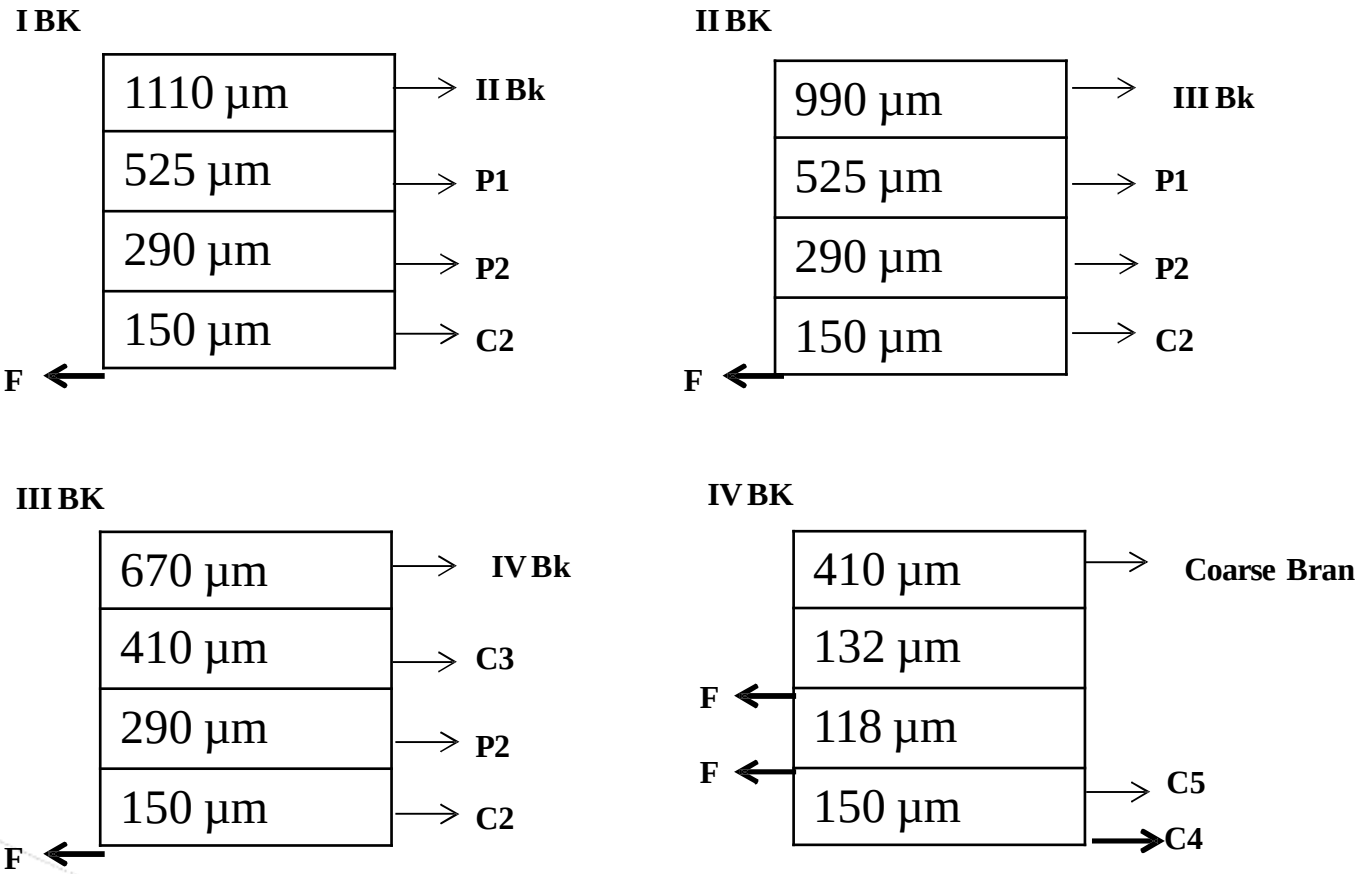
Purification process

Principle: *Separation using air resistance and size*

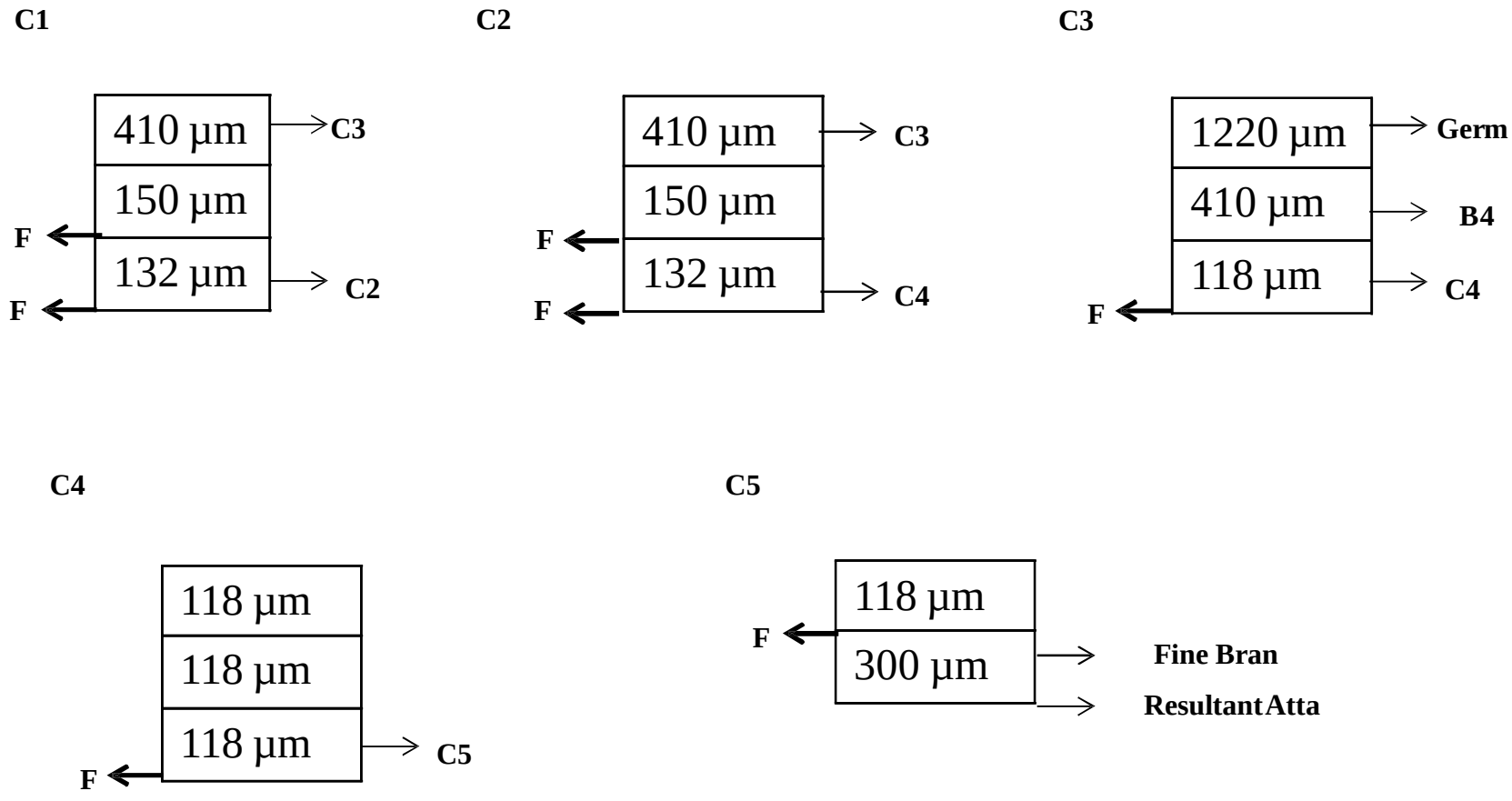
Reduction System

Grind clean endosperm into fine powder

Flow sheet: Break System



Flow sheet: Reduction System



Over and Under Sifting

Over sifting:

- Less stock-more sifting area
- Friction may result in cutting of bigger particles in smaller ones
- Bran specks-high ash

Under sifting:

- More stock-less sifting area
- Yield loss
- Floating on next passage

Restoration: Replacement of nutrients lost during food processing to the original levels present or based on restoring levels to that of a 90% extraction flour.

Enrichment: Practice of adding back only those micronutrients that are lost during milling and for which there is good evidence that a deficiency exists within the general population.

Fortification: Adding nutrients whether or not they are present in the food, or adding levels that are much higher than any natural content. For example, adding vitamin A to wheat flour is fortification rather than enrichment because wheat does not contain vitamin Ain its original state.

Whole Wheat Flour Milling

Wheat

Wheat In India

- Wheat (*Triticum spp.) is the second most important cereal in India after rice.*
- Historically, wheat has been a staple food with the high level of consumption largely unaffected by changes in its price.
- Wheat provides more than 50% of the calories to the people who mainly depend on it.

Wheat Production in India

•India has witnessed a significant increase in the wheat production over the years and has touched 84 MMT in 2010

•There has been linear increase in the production from 44.3 MMT in 1987 to 80.6 MMT in 2009 with moderate growth rate of 2.27

•About 91% of the Indian wheat is produced in six states viz., Uttar Pradesh(34%), Punjab(22%), Haryana(13%), Madhya Pradesh(10%), Rajasthan(9%) and Bihar(6%)

•Wheat productivity in India is 3.1 tons/hectar

•Punjab (4.3t/ha) and Haryana (4t/ha) have the highest productivity than other wheat producing states

•Contribution of Uttar Pradesh and Madhya Pradesh is due to relatively large area (about 50% of total area) sown to wheat

Year	Quantity (Million Metric ton)
2016	93.50
2015	86.53
2014	95.85
2013	95.91
2012	94.88
2011	86.87
2010	80.80

Source: Survey of Indian Agriculture

•There were significant ups and downs between 2001 and 2007 due to unfavorable weather conditions. However from 2007 there has been a steady rise

Global Wheat Scenario

- Globally wheat is grown in 122 countries producing nearly 700 million metric tons
- India is 2nd largest producer of wheat and is maintaining the position from last eight years
- India accounts for 12.05% of the total world wheat production, which is next to China accounting 18.41%

Country	Quantity (MMT) 2016
China	131.6
India	93.5
Russia Federation	73.29
USA	62.85
Canada	30.48
France	29.5
Pakistan	26.00
Germany	24.46
Australia	22.27
Turkey	20.06

Source: FAOSTAT

Wheat Utilization in India

•Close to 80% of the wheat produced is consumed in the country; rest is stored or exported
•Utilization: Food, feed, seed and others (mainly industrial)

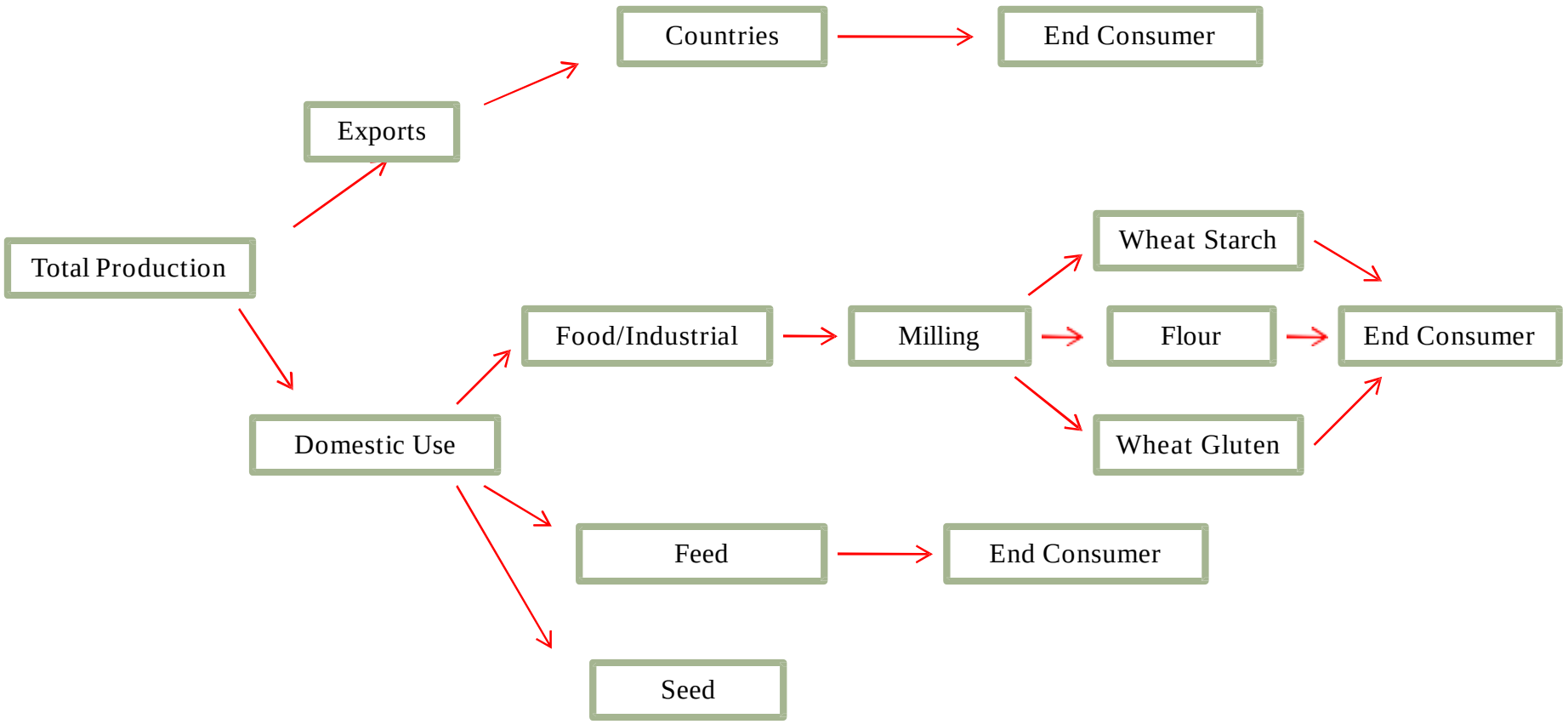
•Food: Major use of wheat accounting on an average two thirds of the total wheat consumption

•Feed: Wheat is excellent for poultry; however, its use as feed is highly variable and depends on the price relationship between other feed grains and its production in any given year

•Seed: About 7% of wheat utilization is seed

•Others, mainly industrial use accounts for 6% (includes processing into starch and gluten)

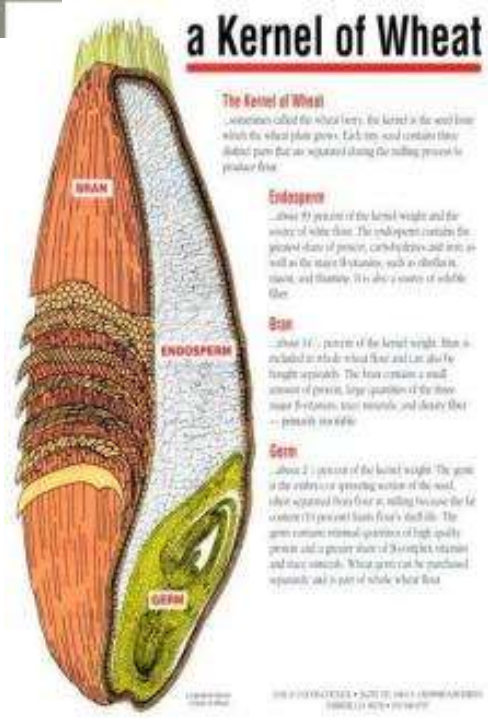
Wheat Value Chain



Where flour comes from?

Flour categories

- **Whole wheat flour**
- **Refined Flour (maida)**



- Whole wheat flour contains all grain parts; Endosperm, branand germ
- Refined flour is made from endosperm only

Wheat Processing Methods for flour

•Wheat is processed to get flour in two ways:

- Roller Flour Mill(Maida, Rawa, resultant atta, bran)
- Stone Chakki (Atta)

•Roller Flour mill is an undertaking capable of processing wheat into different products like Maida, Rawa, Resultant Atta, Bran by gradual reducing system using series of chilled cast iron break and reduction rolls as against sudden death system prevalent in stone chakkis.

•Roller Flour Mill is also capable of making different types of Maida to suit customer's specifications and also vary the product mix as per the market needs.

•Wheat in India is consumed mainly in the form of unleavened flat bread known as chapatti

•Aestivum wheat is milled to get whole wheat flour(atta) for chapattis, poories and paronthas; and refined wheat flour (maida) for pan bread, biscuits, cookies, crackers; and semolina for traditional products like rawa idli, upma, halwa

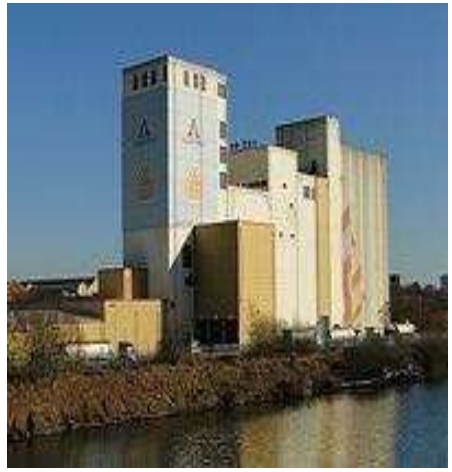
•Durum wheat is milled into semolina for pasta products and traditional products like rawa idli, upma and halwa

•Dicoccum wheat is used for cakes, cookies and dalia

Wheat Milling Industry: Brief

•There are about 1000 Roller flour mills in the country

•Atta chakkis (7.5-10KW rating) account to about 27 lakhs



•Out of about 95 MMT of wheat produced in India, about 18-20 MMT is processed in Roller flour Mills

•Around 50-55 MMT is processed in the local stone chakkis

•Industry operates with an average capacity of 60% owing to performance and other technological issues

•Traditionally used smaller size atta chakkis are facing competition from better mechanized chakkis

•The domestic packaged branded atta market, estimated at 3 MMT is about 2-3 % of the total atta market

•The packaged and branded segment is largely dominated by multinationals, although there are also a few big domestic brands such as Shaktibhog, Lal Qila and Rose.

ATTA

- ATTA - the coarse product obtained by milling or grinding clean wheat that contain all its constituents; endosperm, bran and germ
- This is in contrast to refined flour (maida), which retains only the endosperm
- Because atta contains the remains of all of the grain, it has a textured, brownish appearance

ATTA Nutritional Facts (per 100 gm)

- Energy 340 kcal
- Protein 12 g
- Fat 2 g
- Carbohydrates 70 g
- Dietary Fiber 12g
- Minerals 1.5g

Health Benefits

- Atta is more nutritious than maida(refined white flour), although in a flour fortification some micronutrients are added back to the white flour
- Atta contains the macronutrients of the wheat's bran and germ (especially fiber-speed up the passage of food through the digestive tract, help reduce cholesterol, provides a "full" feeling because of its water-absorbing ability)
- Fiber effectively assists the body in moving waste through the digestive tract quickly and frequently, thus reducing the colons exposure to cancer causing toxins
- Atta is a good source of calcium, iron, and other minerals
- **A**tta also contains powerful antioxidants. Selenium, vitamin E, manganese, and phenolic acid all offer extremely valuable protection against free radical damage to our cells.

Nutritional Value comparison of Atta and Maida

Nutrient	Atta (per 100gm)	Maida (per 100gm)
Total Dietary Fiber	12.2g	2.7g
Calcium	25mg	15mg
Iron	3.6mg	1.2mg
Zinc	2.8mg	0.7mg
Selenium	70.7mg	33.9mg
Thiamin	0.5mg	0.1mg
Riboflavin	0.1mg	0.04mg
Niacin	5.7mg	1.3mg
Vitamin E	1mg	0.06mg

History

- Whole grains have been the cornerstone of man's diet for thousands of years. Early civilizations believed grains were so important that each type of grain was thought to be a **true gift from the gods**
- These whole grains were consumed in the whole food form, the *entire* seed was eaten.
- Traditionally fresh Atta was prepared at home by grinding wheat in hand operated homemade stone grinder known as *Chakki.*
- In the 1870s the roller mill technology was built and thus white refined flour was created.

Atta Industrialization

- Late 1980s saw the production of packaged atta at the industry level
- Shakti Bhog was the first brand which started the packaged atta but was concentrated only in North India
- Industrialization started with the wheat being processed into atta on a large scale
- Atta plants have their own integrated cleaning sections
- Grinding section include pairs of motorized stone chakkis with the daily grinding capacity ranging from 10-20 tons per day to up to 250 tons per day

Technology of ATTA Manufacturing

Wheat

↓

Cleaning (removes all the impurities other than sound wheat grain)

↓

Dampening (water is added to take moisture content up to ~ 14%)

↓

Emery (surface bran removal)

↓

Grinding in pair of stone mill

↓

Sifting (Bran removal ~3-5%)

↓

Atta to Storage silo

↓

Packing (gunny bags/ unit packing)

Cleaning

- Separator
  - Separation based on size
  - Impurities Bigger and smaller than wheat are removed
  - Separating media used is sieve

- Aspirator
  - Lighter impurities removed based on air resistance
  - Separating media is Air

- Magnet
- For removing ferrous impurities

- Destone
- Density separation
- Stones being heavier than wheat are removed
- Separating media is Air

- Scourer
- Removes the outer layer (beeswing) by Friction
- Reduction of bacterial count

Different impurities

Total impurities count to about 3%

- **Dampening**
  - Commercial significance
  - Loosens bran
  - To achieve 13% Moisture
  - Done using Flow meter/Automatic Moisture control
  - Mixing of wheat and water done using Dampener

- Fumigation (optional)
  - Normally batch
  - Pest Control (India) PCI

- Emery (optional)
  - Bacteria count goes up a little after dampening
  - Removes outer bran layers of grain
  - For maximum bacteria count reduction
  - However power consumption is very high
  - 2-2.5% collected bran has No resale value

- 1st Break (optional)
  - A pair of rollers
  - Saves power consumption

- Grinding
  - Pair of Chakkies

Stone Chakki

•Wheat is ground between stationery lower stone and rotating upper stone.

•The stone will have the different types of furrows throughout their inner grinding surface such as:

Main furrow Side furrows

Grinding furrows or shallow furrows

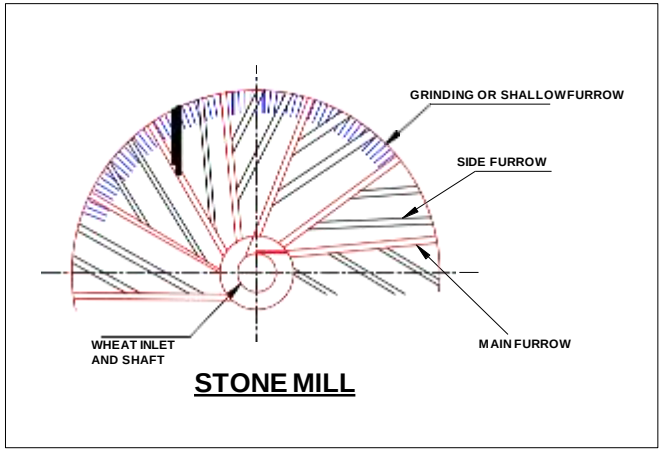
- Furrows main purposes in the grinding process are:

-To shear open the wheat kernels

- To transport the product to the circumference with the help of centrifugal force

- To turn over the product during grinding process

- To support the aspiration of the grinding stones by forming air channels



- Bran removal
  - Plan sifter
  - 3-5% bran removal
- Storage silo
- Packing
  - Gunny bags 90kg
  - Unit packs (laminated HDPE)

- Daily grinding capacity ranges from 10-20 tons per day to up to 250 tons per day
- Depending on the capacity the number of pair of stone chakkis are present

Wheat Blending

Factors for blending

- Adjustment of the protein content of the final product
- Adjustment of price of wheat mixture
- Production of appropriate atta quality to the end users

Critical Steps in Atta processing

- Storage of wheat to avoid infestation as it directly affects the shelf life of Atta
- Removal of the ferrous impurities which otherwise wear and tear the millstones and also affect the quality of Atta
- Gap adjustment between the two stones to get desired granulation and yield of Atta
- To set the stones to get the desired starch damage which is more important in the preparation of soft Chapattis from Atta owing to the water absorption of the Atta

Brand and Multinationals

- Selling almost housewives still buy raw wheat in bulk, clean it by hand, store it, and bring some every week to the mill or chakki, where it is then ground
- India has always been an attractive market because of its size
- Pillsbury (General Mills) were the pioneers in the branded atta category at the national level
- Pillsbury introduced packaged atta in 1998 through a sponsored project with CFTRI
- Different players entered the packaged atta segment sensing the growth of the trend in the near future sooner or later
- CFTRI has consultancy project with ITC for Aashirwad atta
- Even private brands emerged at local and regional level
- Many roller flour mills have set up the chakki plant in their existing roller flour mill plants and started production of their own brand of atta

Major Players

- National Players in the segment:
  - Aashirvaad (ITC)
  - Annapurna (HUL) and
  - Pillsbury (General Mills)
- Pillsbury Chakki Fresh Atta was introduced in 1998 as a high-quality, nutritious alternative to the age-old tradition of purchasing grain and having it ground at the local "Chakki" or flour mill
- Pillsbury Atta with Multi grain: Launched in select cities in 2008, this is a first-to-market, unique blend of seven grains that are specially blended to provide all-around health benefits
- Pillsbury Atta with Multi-Grain offers consumers health, taste and convenience and meets consumers' growing demand for healthier food
- Annapurna atta was launched nationally in 1998
- It had a strong back up of Hindustan Lever Ltd. (Now Hindustan Unilever Ltd.) and the advantage of coming from the No.1 family of FMCG
- Due to its sheer strength of understanding the market and already established distribution network it caught up the market very fast
- It also has the edge of brand loyalty of many consumers
- ITC entered the branded Atta market with the launch of Aashirvaad Atta in Jaipur and Chandigarh on 26th May 2002.
- The product is now available all over India.
- Aashirvaad atta has become the leader in its category with a 45% market share
- Wheat is sourced directly from farmers through ITC's e-choupals
- Aashirvaad Select 100% MP Sharbati atta (Premium Atta) comes from the plush, fertile soil of Madhya Pradesh, tended by the right amounts of sunshine and rainfall directly from farmers through ITC's e-choupals

Major Players

- Of the total national market:
  - ITC-45%
  - Annapurna (HUL)-20%
  - Pillsbury-8%

- Regional Players:
  There are many regional players as well. Shakti Bhog is a strong player in the North. Others are:
  Roshan da atta, Lal quila,
  Priya (Priya Foods Limited) etc.

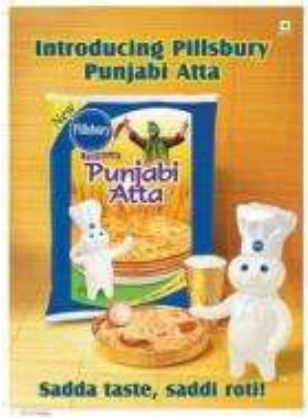
- Private brands include:
  MORE (Selecta, More for you, Mahasaver) FOOD Bazaar (Fresh and Pure, Food bazaar) etc.

Consumer trend

- Consumer behavior is the biggest hurdle in this category.
- Chakki atta carries a very strong perception regarding quality because here the consumer goes through a psychological process wherein he himself selects the wheat and is mentally satisfied because this has been in his tradition.
- The general perception of packaged atta is that it is not of good quality because the consumer does not get an choice to select the wheat which he is addicted to since decades.
- The price is also perceived to be on the higher side and so it is not a major incentive to attract consumers; in normal atta depending on his financial position he selects the wheat and so controls the price
- Other reasons are the freshness and the taste
- However, the advantage that the packaged atta carried over normal chakki atta was that it has very high convenience factor and is a time saving product

Trends in the atta industry

- Retailers are offering and developing their private label portfolio in the wheat flour segment with a healthy mix of national and regional brands to connect with the local communities (Food Bazaar, MORE)
- Many roller flour mills started marketing their packaged atta in their area (catching the market share by luring the retailers giving higher margins compared to the multinationals)
- SEGMENTING the atta: Increased competition in the industry calls for efforts for segmenting and introducing different variants targeting different population
- Value for money (More For You)
- Premium Quality (ITC Select-100% MP Sharbati atta)
- Healthier Food (Pillsbury Atta with Multi-Grain)
- -Region-specific atta (Pillsbury PUNJABI Atta targeting Punjabis living outside their State)



Fortification of Atta: The new Essence

- Micronutrient malnutrition or hidden hunger – is widespread apart from the problem of generalized protein energy malnutrition (PEM).
- Poor most affected by micronutrient deficiencies, but affluent groups not spared due to faulty food habits.
- Fortification of "atta" is one of the several ways of improving nutritional levels of the population
- There is also strong advocacy in place for making available fortified whole wheat flour to end-users through Government's Public Distribution System (PDS) and other Welfare/Feeding Program including Mid-Day-Meal Program; Integrated Child Development Services, etc. as well as through open market sales
- Under this scheme, the State Government, through its nodal agency will issue wheat, those flour mills, which enter into an agreement with the nodal agency for manufacturing and supplying whole wheat fortified atta
- The Govt. of Gujarat started distribution of fortified atta in place of wheat in open market from 2006
- Gujarat is the first State in the country to distribute fortified atta through the Public distribution system; Punjab followed from January, 2008

Future of the atta industry

- Although the relative share of branded vs. unbranded sales is currently minuscule, the sheer size of the market offers tremendous opportunity for growth.
- Packaged atta industry is witnessing the growth of about 25% annually
- As the country gets more and more modernized the penetration of women employment in the country is on the higher side and this is the reason where all time saving products will get the edge and so will packaged atta.
- Rigorous Advertising in the print and the visual media campaigning quality, hygiene, health, convenience factors are helping to boost the salesGrowth has also picked up pace with the Government's proactive approach with the formulation of national food policy

- With the rise of modern retail formats, increasing disposable incomes and health awareness, the category is undoubtedly on the upspring

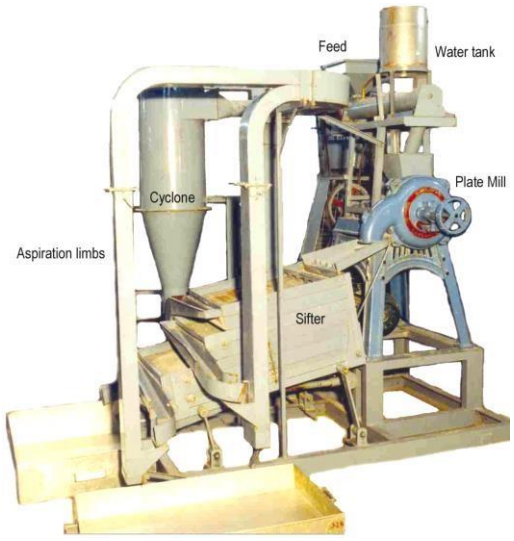
Chapter 3
Maize milling

Maize (*Zea mays),* also known as corn**,** is an important cereal grain. Maize is a staple food in many parts of the world. Maize is an important coarse cereal in India, next only to rice and wheat. It constitutes about one-third of total coarse cereals produced in India. In addition to being consumed directly by humans, maize is also used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. Corn is consumed as human food in many forms. In its harvested wet form, it is consumed as vegetable. The ready-to-eat breakfast cereal corn flakes is made from maize grits. Popcorn the first snack food is undoubtedly the oldest snack food. The majority of corn consumed as human food undergoes milling and is consumed as a specific or modified fraction of the grain.

Maize Milling

Dry milling is the simplest method of producing maize products for human consumption. Grinding whole kernel corn in a grind stone or plate mill to produce flour or meal is a simple method used worldwide when the ground products are to be consumed shortly after processing. When maize is ground to make coarse whole meal extraction rate will be of the order of 85 - 95%. If the whole grain is ground, fibrous bran results in coarseness of the resultant flour. Coarse bran affects flour/dough quality, cooking quality and the digestibility. Also, germ present in the grain is rich in lipids. If the whole grain flour is obtained, germ also gets pulverized and the fat content of the flour will be high. This is responsible for the poor shelf life of the flours. In order to reduce the deleterious effects of antinutritional factors, improve the flour quality and shelf life, maize, as other coarse cereals and millets, is subjected to the process of decortication/ refining. In order to get the desired refined flours, it is necessary to remove the bran layers and/or germ partially,

if not completely. Thus refining of maize includes partial or complete debranning and degerming.



MINI GRAIN MILL

CFTRI, Mysore has developed a mini grain mill which could be used for the production of small sized grits, semolina and flour almost free from bran from maize. The versatile mill can also be used for sorghum and millets. In this unit, an existing plate mill is attached with a water mixer, tempering cum hopper bin, a four-deck sieve and an aspirator system, all units deriving drive from a common motor.

Grains are fed into the main hopper and passed through a water mixer (2 to 5% water) and collected in the hopper of the plate mill. After about 5-10 minutes of tempering, grains are coarsely ground in the plate mill and the resultant milled fraction falls on the sifter deck by gravity. Coarse bran is separated on the top deck and other fractions viz., coarse, fine semolina and flour are collected separately. Pulverized bran coming out with the different fractions is also aspirated off.

Milling of maize either by wet or dry-milling process involves separation of the grain into its components. Fractionation by the two methods differs as the products and by-products required are different. The objective of dry milling is to separate the kernel into its anatomical parts (endosperm, bran and germ); and that of wet milling is separation of maize into its chemical constituents (starch, protein, fibre and oil).

Commercially, dry milling involving de-germing are carried out in large commercial mills. This involves a Tempering and Degerming system to remove most of the germ and hull and leave the endosperm as free of oil and fiber as possible to recover maximum yield of

endosperm and germ as clean grits (of different particle sizes). Typically, in this process, Corn is cleaned to remove dirt, stones, insects, tramp iron, broken kernels and extraneous plant materials. The corn is then conditioned by adding water to increase the moisture content to 20%, and the moistened corn is allowed to equilibrate for 1 - 3 hrs. The objective of conditioning is to loosen the germ and toughen the bran and to mellow the endosperm so as to obtain a maximum yield of grits and a minimum yield of flour in the subsequent milling.

Degerming and dehulling is carried out in one of the following four ways:

1. Beall de-germinator (De-germer and corn huller)
2. With roller mills and sifters
3. With impact machines such as entoleters and gravity separators
4. CFTRIs Indigenous multi-stage dry milling system

Once the germ and hull are removed, the low fat, low fibre grits so produced can be used as such for different purposes. Normally these grits are classified into hominy grits, brewers' grits etc., based on the particle size. Pure degermed grits have better shelf life and good potential for food uses. They can be used to produce a variety of nutritional, traditional foods with high consumer appeal and also have industrial usage (as in brewery). If grits are not used, then these are reduced in size to grits with roller mills. A complex array of additional roller mills and particle size separating equipment are used to purify and size endosperm particles. All products must be dried prior to packaging or bulk storage.

Wet milling of corn is achieved by a combination of chemical and mechanical means. Wet milling begins with steeping of cleaned corn for 30 - 48 hours with water. Sulfur dioxide is added to the water at the rate of 0.1 - 0.2% and the solution is heated to about 50^{o}C. This condition prevents growth of putrefying microorganisms. During steeping, the kernels absorb the solution and swell, activating enzymes present in kernel to assist in breaking down the structure; the bisulfite ion reduces disulfide bonds in the protein matrix, increasing protein solubility and diminishing interactions between starch and protein; the lactic acid and/or exogenous enzymes produced by the lactobacilli help soften the

endosperm. After steeping, maize is subjected to wet grinding and fractionating in disc attrition mill. The ground slurry is then pumped to hydroclones (liquid/ hydro cyclones) to separate lighter-weight germ. The germ is dried and processed for extracting corn oil and meal. The heavier underflow from the hydroclones is screened, and larger particles are finely reground with an impact mill to free the starch, protein, and fiber from each other. Fiber is separated and washed over a series of screens. The remaining stream of starch and protein is passed through disc nozzle type centrifuges, where heavier starch is separated from the gluten. The gluten is dewatered using additional centrifuges and vacuum filters. The remaining starch slurry is washed and passed through hydroclones. Centrifuges and/or vacuum filter dewater the purified starch.

A popular product based on corn starch is Corn syrup, a food syrup and is composed mainly of glucose. Corn syrup is used in foods to soften texture, add volume, prevent crystallization of sugar, and enhance flavor. Corn syrup is distinct from high-fructose corn syrup created when corn fructose syrup, syrup undergoes enzymatic processing that produces a sweeter compound containing higher le levels of fructose. The more general term glucose syrup is often used synonymously with corn syrup, since glucose syrup is most commonly made from corn starch.

High Fructose Corn Syrup (HFCS), is a sweetener made from corn starch. As in the production of conventional corn syrup, the starch is broken down into glucose by enzymes. To make HFCS, the corn syrup is further processed by glucose isomerase to convert some of its glucose into fructose. As a sweetener, HFCS is often compared to granulated sugar, but manufacturing advantages of HFCS over sugar include that it is easier to handle and more cost-effective. HFCS is made in a few concentration levels and finds use in processed foods and breakfast cereals, and in the production of soft drinks.

Apart from these methods of consumption, a major portion of maize is converted to *masa*, in Mexico and the US, to prepare *tortilla*. The process of producing masa flour/ dough is nixtamalization, which is nothing but alkali cooking of the whole grain. This is also picking up slowly in India, as Mexican foods are gaining popularity in the metropolitan cities.

Maize is a wonder grain that could be exploited for food, feed and industrial uses, if properly processed.

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Chapter -4
RICE MILLING TECHNOLOGY

Introduction

Rice milling is the most important post harvest process that produces edible rice from paddy. Paddy seed contains a rough, inedible, woody outer covering called husk. The inner kernel, called brown rice, again contains some soft outer layers, jointly called bran. The process of removing husk and bran layers (partially or fully) from the paddy grain in order to produce edible rice is called Rice milling. Dehusking is the step of removal of husk. After dehusking paddy, we get brown rice. Debranning is the process of removal of different layers bran (pericarp and the testa, the aleurone layer and germ, partially or completely) from brown rice. This produces the edible milled rice or the white rice.

Unlike other food grains, rice is mostly cooked and consumed in the whole grain form. Loss of kernel integrity results in brokens. Production of brokens means quantitative and qualitative loss of edible rice. This also means reduction in the marketable price and poor economics. The milling yield of rice is determined by factors like husk content of the paddy variety, degree of milling and grain breakage. Moisture content, variety and type of paddy (raw/parboiled) and rice milling machinery affect milling yield. Shortcomings in all the pre and post-harvest operations show up during rice milling.

Rice milling operation should ideally maximise the yield of good quality edible rice, minimise losses and processing cost. Milling equipment ranging from the simplest pestle and mortar or a *dhenki* to the large, modern computer controlled complex systems are employed for milling. Hand pounding used to be part and parcel of village life. The range of equipment available in the market for rice milling is also expanding continuously. Understanding the principles of operations and the most commonly used equipment used for rice milling is of utmost importance.

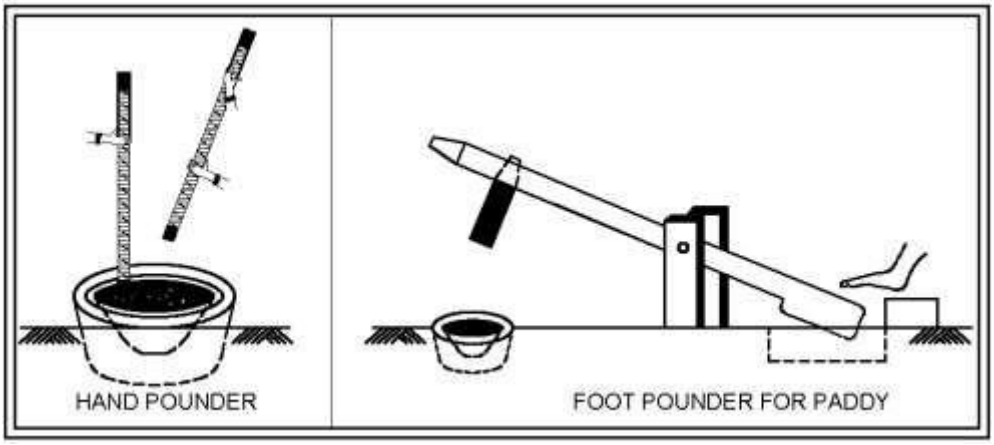


Fig. 1 Traditional Milling Methods

Modern milling technology

A flow chart of important operations, followed in sequence, for milling of rice in a modern rice mill shown in fig 3. The operations are as follows:

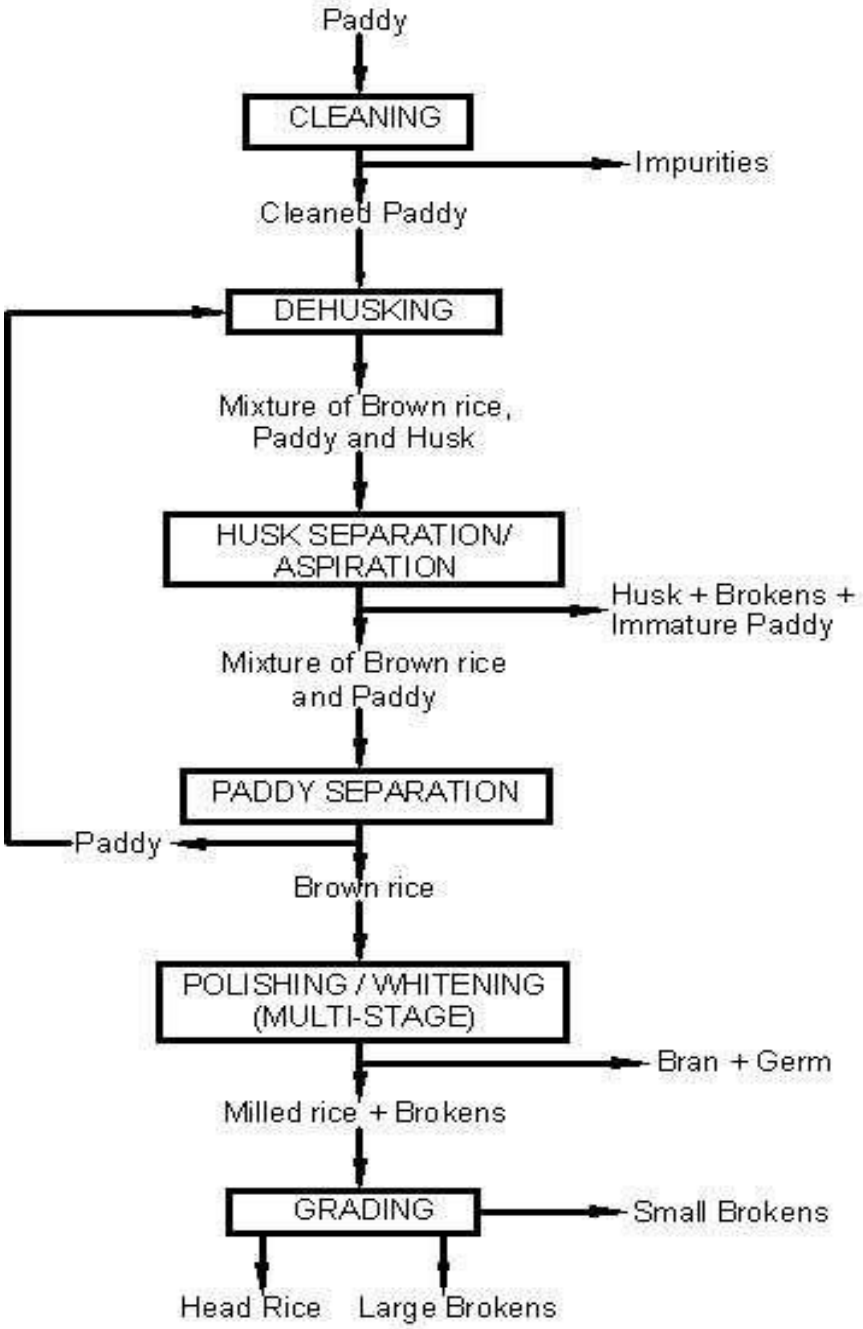


Fig.3 Schematic diagram of rice milling operations

Cleaning	Removes foreign matter such as sand, stones, straw, seeds of other grains and pieces of iron from paddy.
Dehusking	Removes husk from paddy with minimum damage to the grain.
Husk separation	Removes husk from the mixture obtained after dehusking.
Paddy separation	Separates brown rice from remaining unhusked paddy, paddy being returned for dehusking.
Debranning	Removes all or part of the bran layers from brown rice to produce polished rice.
Grading	Separates brokens from head rice. Brokens are separated into different sizes.

Bucket elevators are used to move the grain from one machine to the next for continuous operation. Conveying, bagging, weighing and other associated operations are also done as required. The standard sizes of the plant and machinery are 1, 2 and 4 tonnes paddyper hour, though 6 TPH plants are also being introduced now.

Major difference in different types of rice mills can be seen in the application of cleaners, paddy separators and polishers. Compartment type paddy separators and cone polishers are adapted in one type of mills whereas the other type uses drum type cleaners, tray type paddy separators and horizontal type- primary and final polishers. Combination of the two types is also very common. Cone polishers are generally preferred for milling parboiled paddy.

A short description of the different steps and of machines used for each step in milling is as follows:

CLEANING:

Cleaning is the process of separation of impurities from the paddy stock. Paddy arriving in the mill usually contains foreign matter (materials other than paddy grain). These contaminants usually get mixed in the field and during handling and transportation. Upon arrival at the mill, foreign matter should be removed from paddy stock. Cleaning, therefore, is the first step in modern rice milling. Cleaning not only enables the production of cleanrice but also protects milling machinery and improves milling capacity.

Differences in the physical characteristics of paddy and impurities are used in the cleaning process to bring about separation of impurities from the mill stock. Based on the size, impurities are classified into large impurities, small impurities, and impurities as the same size of paddy. Large impurities normally consist of rice straw, panicles, bag string, soil, stones and some times, iron parts. Small impurities consist of dust, sand, mud balls, weed seeds, insects and small stones. Impurities of the same size as paddy can be immature, empty grains, stones and iron particles. Impurities which are larger or smaller in size than paddy are removed by sieves. Vibrating or rotating sieves or a combination of both can be used for this purpose.

Lighter impurities are removed by aspiration. This also creates a hygienic work environment. Ferrous impurities are removed by the use of magnetic separators. Impurities of the same size of paddy, but heavier are removed by destoners/ specific gravity separators. Cleaners may have builtin destoners. Often, intake paddy is subjected to a preliminary partial cleaning (scalping) prior to storage and mill cleaning.
In some old/ traditional mills, open type, two-sieve reciprocating sifters are employed. Only size separation is possible in these units. Being an open system, dust formation is considerable. Sieves also get clogged and the cleaning efficiency will be low.

Modern rice mills will have improved cleaners. A few types of more popular cleaners are described herein.

A. Closed type double action cleaner:

Paddy is fed into this machine through the inlet opening at the top. The suction fan draws air through the moving bed of grains and separates dust and light impurities which drop to the cone-shaped bottom of the aspiration housing for automatic discharge. Paddy falls on to a vibrating sieve with large perforations which removes large impurities such as straw, big stones etc. Paddy and remaining small impurities fall to the bottom vibrating sieve with small perforations which removes small impurities. Overflow from this sieve is again subjected to strong aspiration to remove the last traces of light impurities and dust.

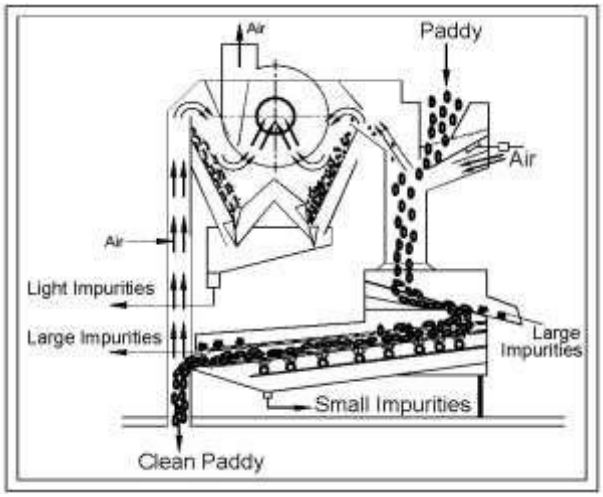


Fig. 4 Closed type double action cleaner

B. Drum type cleaner:

In this type of cleaner, paddy flow is made uniform by thorough distribution of stock, while feeding into the rotating scalper. Straw and other comparatively large impurities are flipped out of the scalper and discharged separately. Small pieces of straw, light impurities, dust and very light immature grains are exhausted by means of an in-built blower. The cleaner may also have an in-built destoner.

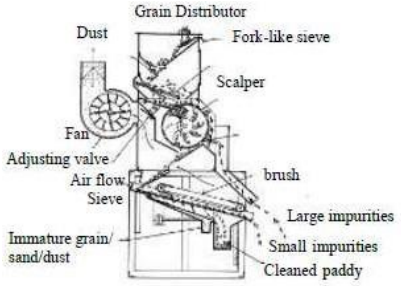


Fig. 5 Drum type cleaner

C. Sieve Separator:

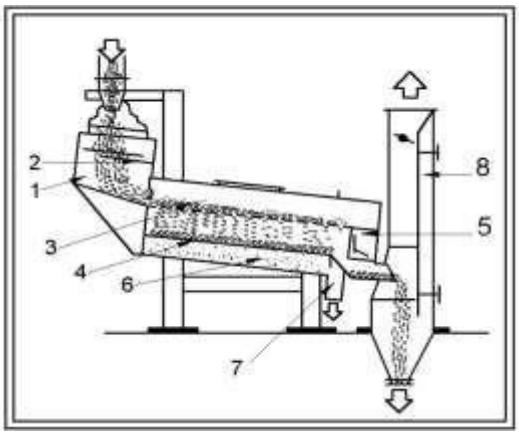


Fig. 6 Sieve Separator

In these cleaners, a set of sieves gyrate. The machine makes three separations by size: foreign matter larger than paddy, paddy and material smaller than paddy. In addition, material lighter than paddy is subjected to thorough aspiration.

The stock is fed by a gravity spout into the center of the inlet box (1) oscillating with the machine. A distribution baffle (2) with adjustable slide gate distributes the stock across the entire width of the screen. Then the stock flows over the upper screen (3). The throughs from this first screen drop onto the lower screen (4), while the overs are discharged laterally through the outlet section (5). The throughs of the second screen drop onto the bottom screen (6), which is removed at the outlet (7). The overs from the second screen are subjected to aspiration. The air flow rate is adjusted by changing the cross section of the aspirator limb portion by setting the plate (8).

DESTONING:

Impurities such as stones, dirt (mud balls), or metal pieces about the same size as paddy flow out with the stream of grains from the "sieve-aspirate" type of cleaners. Based on differences in density of grains and stones, destoning is achieved. These machines can be of two types, viz., blowing type (pressure type) or suction (vacuum) type.

Pressure type Destoner:

The destoner consists of a reciprocating perforated deck mounted at an angle. Requisite quantity of air is blown from below through the sieve. When paddy containing stone/ heavier impurity is fed at the top of the sieve, air coming through the sieve stratifies the materials according to their density. The heavier impurities (stones) remain on the deck and are carried backward to the top end by the reciprocating motion of the deck and discharged. Paddy remains floating and slides down the incline. Separation can be adjusted by regulating the rate of feed, volume of air and sieve inclination.

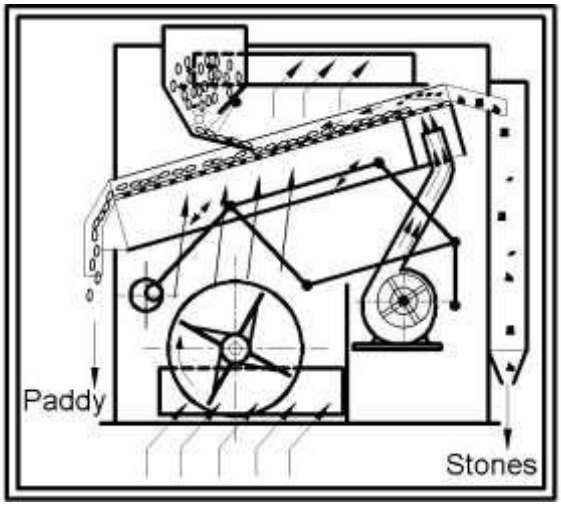


Fig. 7. Destoner

Vacuum type destoner:

Working principle of these units is similar to the pressure type destoner, except that air is sucked through the grain bed from the top of the deck.

In these units, grains are spread uniformly across the entire width of decks by a feeder. On the pre-separation screen, material is stratified according to specific gravity by the oscillating motion of the screen and the air flow i.e., Light materials collect at the top while the heavier ones-including the stone, get to the bottom. The lower layer, which also has the stones, flows upwards and is fed to the final separation zone. Here, stones are separated by a counter-current of air.

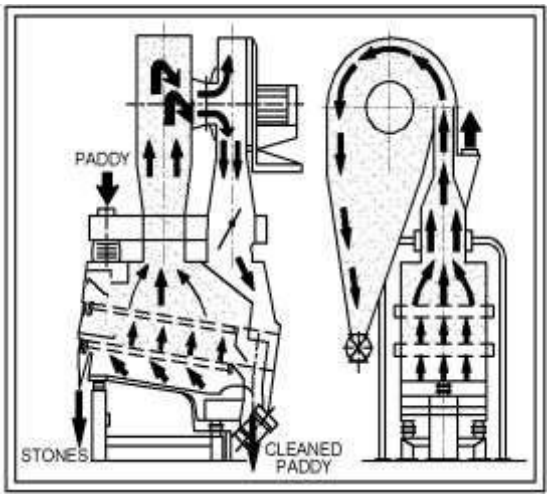


Fig. 8 Vacuum type destoner

Stone-free materials on the two screens, supported by air cushion are discharged at the outlet through rubber valves. Inclination of the screens and the volume of air can be adjusted to achieve optimum separation. These stoners are also available with air-recycling system, as shown in fig 8.

Magnetic separator:

Magnetic (ferrous) impurities are separated from the paddy stock using magnetic separators. Type A is a permanent magnet located in such a way that when unclean paddy moves across it, the iron particles are collected by it. The particles are later cleared manually. Type B is cleaned automatically. The rotating cylinder is turned by the free-flowing paddy. Under the cylinder, there is a half-round magnet. As the paddy passes over the cylinder, iron particles are held by the cylinder's

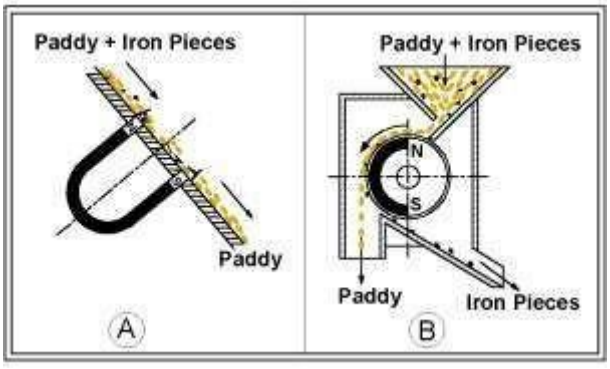


Fig.9 Magnetic separator

magnetic attraction. As the cylinder continues to rotate, when the cylinder is not moving over the magnet, the iron is automatically released and discharged separately.

Cleaned paddy is then taken for the next stage of milling i.e., Dehusking.

DEHUSKING:

The objective of dehusking is to remove the husk from paddy without breaking the brown rice grain. During this process, it is also important not to induce damage to the bran layers. Dehusking was being performed by different types of machines: disc sheller, centrifugal sheller, rubber-belt sheller etc. All modern rice mills now use rubber roll type dehuskers. Details of some of these shellers are presented below:

Disc sheller:

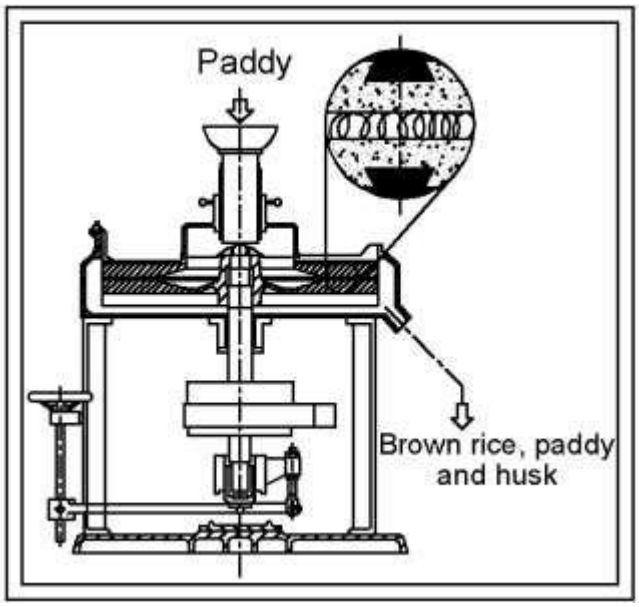


Fig. 10 Disc sheller

This type of dehusker basically consists of two cast iron discs coated with an abrasive material such as emery. The upper disc fixed to the frame remains stationary while the bottom disc rotates. Therefore, it is also called `under runner disc sheller'. The rotating disc can be moved vertically up or down and the clearance between the two discs can be adjusted to suit the size of paddy. Paddy is fed through the central feed hopper and the centrifugal action causes radial movement of paddy outward between the discs. During its travel outward, whenever paddy is up-ended, it is caught between the two discs and is dehusked.

Clearance between the two discs is critical to avoid excessive breakage. As the grain has to travel across the entire breadth of the emery disc, some rice breakage does occur in this machine. Some polishing also takes place for the same reason, causing loss of bran. Dehuskers of this type of have now become obsolete.

Centrifugal sheller:

It consists of a high – speed rotating impeller disc surrounded by a stationary rim made of rubber. Paddy is fed in to the disc rotating at a very high rpm. Due to the centrifugal action, grains are forced against the rubber rim. The husk gets cracked by impact, and shelling is effected. Some breakage does occur, especially in the case of dehusking of raw paddy. Shellers of this type are available in small capacity range and are generally preferred for dehusking parboiled paddy only.

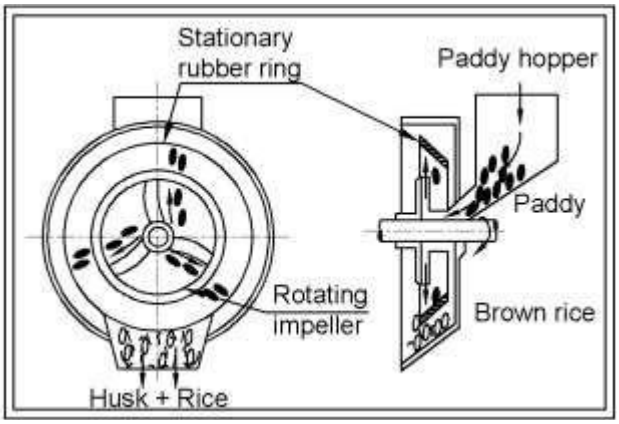


Fig. 13 Centrifugal sheller

Rubber-roll Sheller:

These are the most commonly used type of dehuskers in the modern rice mills. In fact, modern rice mills are characterized by the presence of these types of shellers.

Rubber-roll sheller consists of two rubber rollers rotating in opposite directions at different peripheral speeds. One roller is fixed in position and the other is adjustable laterally in order to adjust the clearance between the two rolls. These rollers are generally spring loaded (however, the newer machines have a pneumatic system). The difference in peripheral speed along with the spring load subjects the paddy grains falling in to the roll nip to compression and shear which strips off the husk. Rolls are cooled by blowing air on the roll surface. Comparatively higher shelling percent can be maintained in these shellers as compared to others.

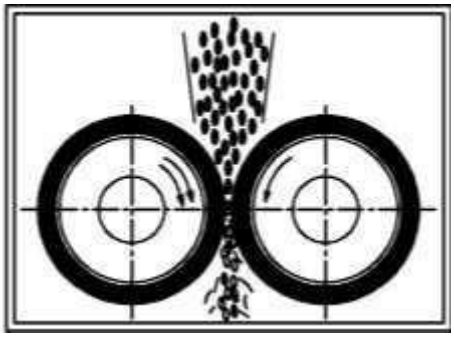


Fig. 14. Shelling action in RR sheller

For efficient dehusking, compression and shear forces should be at the optimal level. Also, during operation, there should not be roll-to-roll contact, as this leads to generation of excess heat, wear and tear and discoloration of grains. Effectiveness of rubber roll sheller depends on: Circumferential speed of the rolls, Speed differential between the rolls, Pressure between rolls, Roll hardness, Gap between the rolls and Feeding rate and uniformity.

As regards the absolute value of speeds, higher the circumferential speed, higher is the capacity. But, speed is restricted by grain breakage, development of excessive heat and stress on the rubber,

shearing and failure. In normal circumstances, circumferential speed is limited to 13 m/s. Greater the speed differential, stronger is the shearing effect. However, if this is too strong, grains tend to break due to excessive strain. Speed ratio of the slow to fast rollers may lie between 0.75 to 0.8, corresponding to a difference of about 2 ms^{-1} in their absolute speeds. Low compressive pressure between the rolls results in lower dehusking. But if this is increased beyond a limit, it results in higher breakage of rice. Low rubber hardness results in higher wear and poor life of rubber rolls while with higher hardness, grains break. Hardness of rubber should be about 90 shore number. Generally, gap between the rubber rolls will be kept at half the thickness of paddy. Larger gap would result in lower dehusking percent and smaller gap results in stripping of bran layers/ grain breakage/ excessive roll heat/ vibration and noise. If the feeding all along the roll length is not uniform, rolls wear locally, resulting poor life of rolls.

During dehusking, rubber rolls wear out due to roughness and abrasive nature of paddy husk. Due friction during dehusking, temperature of the rolls increases. Heating results in softening of rubber and increases wear rate. Due to the difference in speed of the two rollers, the wear rate of rolls is also not uniform. This causes changes both in the absolute and differential speeds of the rollers resulting in poor hulling efficiency. To obtain more operational life per pair of rubber rolls, they should be frequently interchanged to ensure uniform wear. It is better to interchange rolls for every 2-3 mm of wear.

Life of rubber rolls:

Durability or life of the rubber rolls varies with cleanliness of paddy, moisture content, pressure applied to the rolls, working temperature of rolls, paddy variety (abrasiveness of the husk, short or long grain) as well as the quality/hardness of rolls. A pair of good quality rubber rolls is generally expected to give a life of about 100T for raw paddy and 200 T for parboiled paddy. Life of rolls is generally high for parboiled paddy because during the course of parboiling husk would have opened out making dehusking easier. Experiments conducted indicate that the rolls used between the third and sixth month after manufacture give optimum life.

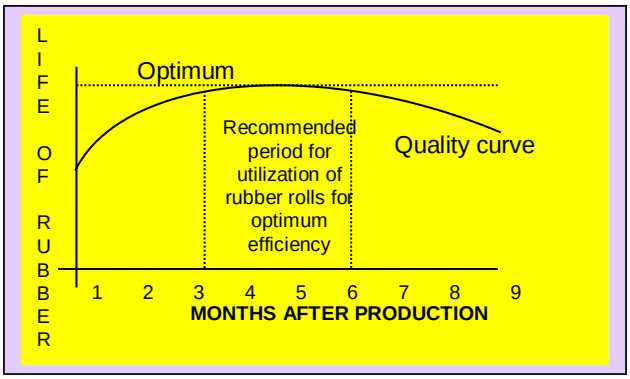


Fig. 14 Milling capacity rubber rolls Vs Age

HUSK SEPARATION

Shellers produce a mixture of brown rice (whole and broken), unhusked paddy grains

and husk, sometimes even bran and germ. Separation of these fractions involves size separation and/or aspiration. Sieving prior to aspiration helps in separation and recovery of brokens, which would otherwise be carried away along with husk. Immature paddy is also collected separately after aspiration. Units which employ both sieving and aspirating units are called Husk separators.

Husk Separator:

Mixture of paddy, brown rice, brokens and husk are fed at the top of a vibrating sieve. The brokens pass through the perforations of the sieve. As the mixture of husk, paddy and brown rice overflows from the sieve, air is blown or sucked through the mixture. Husk is carried away by the air. Paddy and brown rice are collected separately.

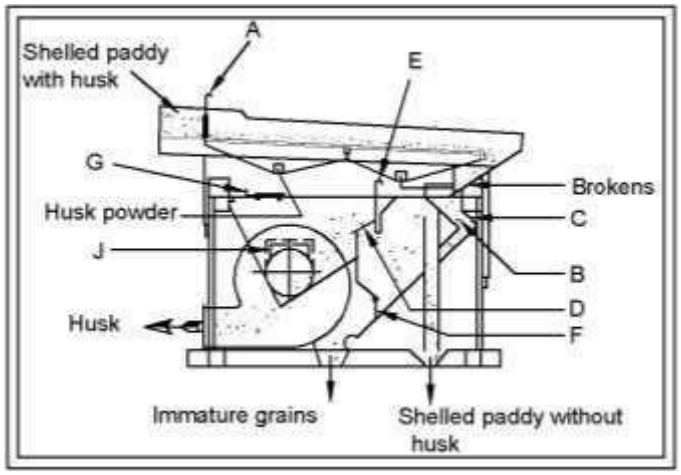


Fig.15 Husk Separator

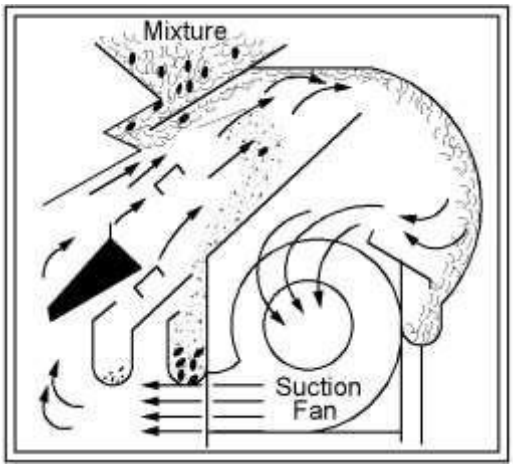


Fig.16 Husk Aspirators (Suction type)

Husk Aspirator:

Aspirators employ only the method of aspiration to separate husk, brokens and immature paddy from brown rice. Husk aspirators are available both in blowing and suction modes.

Generally, husk aspirators are mounted just beneath the shellers for gravity feeding of the mixture.

PADDY-RICE SEPARATION

Shelling is never done to 100% level to avoid rice breakage. Also, since grains differ in size, so that the smaller grains tend to remain unshelled. Thus, the resultant product after dehusking and husk separation is a mixture of brown rice and paddy. To polish this mixture, higher milling pressure is required and this results in higher breakage and lower milling yield. Therefore,

separation of paddy from the mixture is important and for this reason, paddy separators play a vital role in the rice milling process.
Separation is effected in the separator by taking advantage of the differences in density, size and surface smoothness (or roughness) of paddy and brown rice.
Two important kinds of paddy separators commercially used are: a. Compartment type and b. Tray type

Compartment type paddy separator:

The operating principle is based on the different behaviour of apparently similar bodies when moving over an inclined plane. The different speeds at which they gravitate are related to their specific gravity, shape, contact area and coefficient of friction. If a body is small, heavy, round and smooth, it slides down faster than the one which is bigger but light, flat and rough.

The machine applies this principle by spreading the mixture of paddy and brown rice over a sloping surface and giving equal, intermittent, obliquely upward thrust. The thrust so is regulated that it cannot push up the rounder, denser and smoother brown rice. Flatter and rougher paddy grains of low density cannot however, overcome the upward thrust and move up the incline causing paddy and brown rice to move in opposite directions and fall off at the opposite sides of the sloping surface.

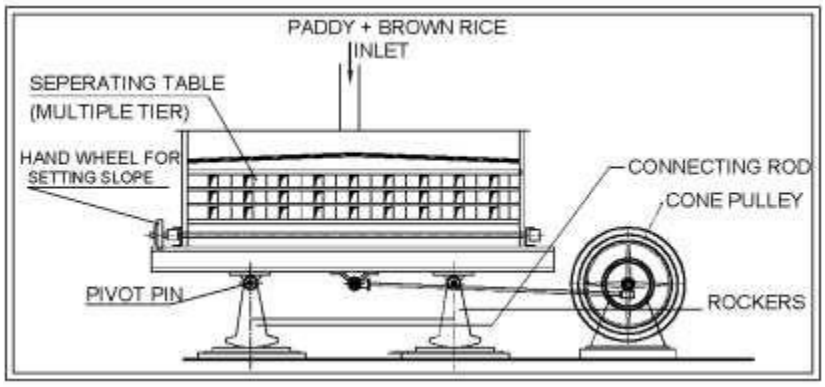


Fig.17 Compartment Paddy separator

The compartment separator consists of three main parts viz., feed box, table and the frame work carrying the drive mechanism. For efficient functioning of the separator the feed box should provide an even and constant supply of material to each compartment without stratification. The oscillating table is divided into zig zag channels and is inclined from one side to the other along the zig zag channels. Surface of the table is of smooth steel. The table oscillates cross wise i.e., perpendicular to the direction of channels. In the conventional system, the table frame is held by rockers to impart the reciprocating motion by an eccentric mechanism. Number of strokes of the

table is varied by altering the number of revolutions of the drive shaft by sliding the flat belt on the cone pulley. In the improved compact versions of the separator, driving parts are mounted under the table itself and rpm is varied a variable speed gear. In another improved version, stroke of the table is made variable. The typical rockers are replaced by the rubber coated rollers and the table slides on these rollers. The slope of the table is altered by changing the position of the roller pivots using the hand wheel.

The mixture of brown rice and paddy is fed from the feeder to the center of the channels. The impact of the grains on the sides of each channel causes the unhusked paddy grains to move up the inclined slope toward the higher end of the table. The dehusked brown rice slides down the slope to the lower side. The slope and stroke of the table are adjusted to ensure complete separation.
Usually there are several decks one above the other to get the required working capacity.

Tray separator:

This machine works on the principle of the differences in the size, specific gravity and surface roughness of paddy and brown rice. The tray or deck type separator will have indented decks. These decks are inclined at a fixed slope in lateral direction and inclination along the longitudinal axis is adjustable. The trays oscillate. The tray section moves up and forward, making a slight jumping movement.

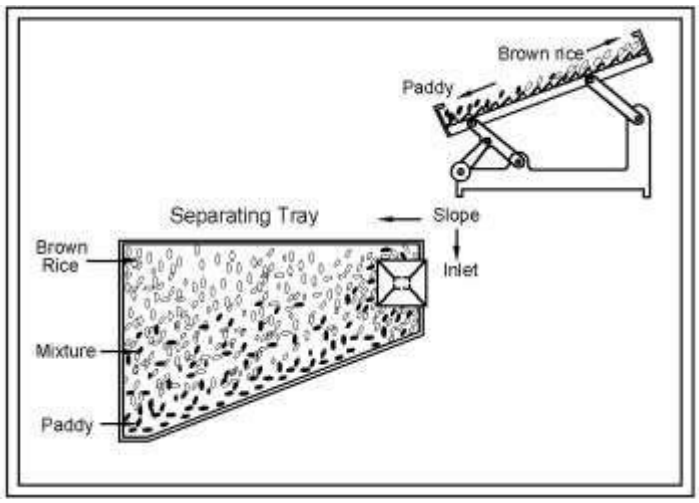


Fig.18 Tray type separator

When the mixture falls on the tray at the top corner from the inlet hopper, smoother, smaller and heavier brown rice tends to move downwards and paddy floats up due to the motion of the tray. Further, brown rice being smaller is caught in the indentations and move upwards with each jump of the tray. Free flowing paddy slides downwards and is discharged there. Unseparated paddy-brown rice mixture remaining in the middle portion is discharged in between and is returned to the feed hopper for recirculation. The tray inclination is adjustable to meet different grain sizes and conditions.

Separation efficiency of paddy separators depends on the speed, stroke, feed and inclination. They have to be properly set and monitored for optimal performance. Improper setting would result in brown rice going with return paddy or return paddy going with brown rice, or both, affecting capacity of the plant and the yield and quality of milled rice.

Paddy collected from the separator is called return paddy, for it has to be returned to the sheller. The return paddy grains are shorter (if in disc sheller) or thinner (if in rubber-roll sheller) than normal paddy. Hence, it is preferable to shell it with closer clearance between the discs or rolls. Brown rice is carried forward to the next stage viz., debranning.

DEBRANNING

Objective of polishing is to remove, to a greater extent, outer layers of brown rice viz., the pericarp, tegmen and aleurone layers, as well as germ – collectively called bran. Bran is rich in pigments, fat, fibre and ash. Debranning is essential for easy cooking and digestion, although excessive polishing reduces the nutritive value of rice. Removal of the outer layers of bran is called whitening. Bran obtained during these stages would have more fibre. Polishing is the next step wherein the rice is made to get the polish/finish/glaze. Bran obtained during these stages is likely to have more oil (initially), and starch (scoured endosperm). `Whitening' is also called primary polishing and `polishing' (also called pearling) is called secondary/final polishing.

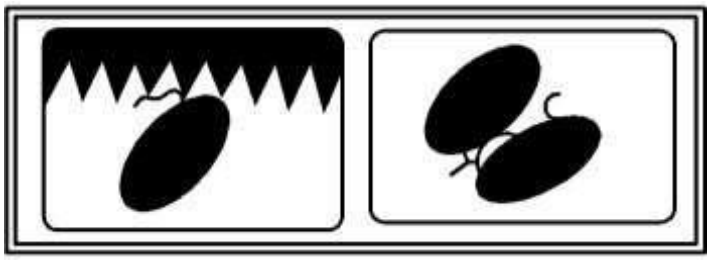


Fig.19 Principles of debranning

The principle of polishing is quite different from than that of dehusking. Husk, though encloses the caryopsis quite tightly, it does not adhere to the grain. But, bran layers wrapped on the endosperm are deeply embedded and fused together.

Also, rice has a unique cono-ellipsoid shape which generally also would have ridges and furrows on its surface with varying depths of bran layers covering it. Therefore, bran cannot be removed layer-wise on all sides at any degree of milling. The extent to which these layers are removed is indicated by `degree of milling' of rice. This is calculated as the percentage by weight of brown rice removed as bran during milling.

There are two types of polishers, one of emery and the other of metal. The abrasive (emery) polishers (called whiteners) polish the grains by abrasion with emery while the friction (metal) polishers polish by friction between the rice grains. The manner of removal of bran from abrasive and friction rollers differs. The abrasive roller acts as a blade to cut and remove small bits of the bran layer from the brown rice. The process is similar to cutting off an orange skin little by little in small pieces with a sharp razor blade. But in friction type machines, bran is removed in rather big flakes just like peeling of the skin of an orange.

Friction, cutting, grinding and impact forces may be present in varying degrees in all the types of polishing machines. It should not be misconstrued that in Friction type of polisher only frictional forces are acting and in abrasive polisher only abrasive forces would be present, though that would be the predominant one.

Abrasive type of polishers:

In these units, brown rice is scraped against an abrasive surface and the outer part is cut away as if scraped off by a knife; meanwhile each grain rubs against each other and against other parts of the milling chamber and bran layers are taken off. Abrasive polishers are of two types – vertical and horizontal.

Vertical type abrasive polishers:

a. Cone polisher:

The whitening cone consists of an inverted truncated cast iron conical rotor covered with an abrasive material like emery. Mounted on a vertical spindle, the cone revolves inside a crib. The crib is lined with steel wire cloth or perforated metal sheets and is provided with vertically and equally spaced rubber brakes, which protrude into the interstitial gap between the cone and the crib. As the rotor shape is conical, this allows for gap adjustment between the cone and the crib by moving the cone up and down.

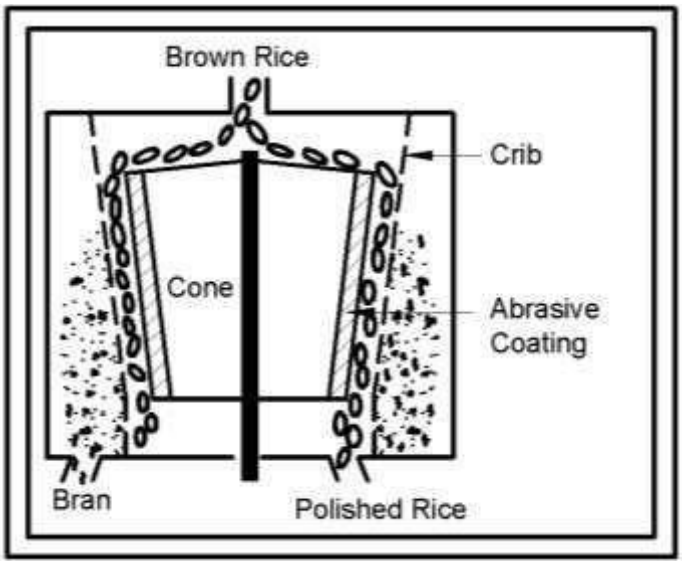


Fig.20 Cone Polisher

Brown rice that enters at the top of the rotor moves outwards by the centrifugal force to the annular space and is dragged along by the rough surface of the rotating cone. The rubber brakes tend to stop it and cause it to pileup against their sides. While pressed up against the brakes, grains undergo a strong swirling and revolving movement because of their oval shape and smooth surface.

Grains are scoured by the abrasive surface of the cone and also by the friction as grains are rubbed against the surrounding ones as well lining of the crib. The grains revolve around the cone in the gap until their own weight causes them to sink lower and lower. Finally the rice is discharged at the bottom of the cone.

The bran layers are allowed to pass through the openings in the crib. Bran, because of its high oil content `lubricates' the grains making scouring and rubbing less effective. Therefore, bran is to be removed from the polishing zone, as it is produced.

Construction:

A cone polisher as shown consists of an inverted cast iron, frusto-conical rotor, which is hollow inside with outer surface covered by an abrasive compound. The rotor revolves concentrically, on a vertical spindle inside the crib lined with perforated sheet metal or wire cloth. The crib is divided into sections by rubber blocks or brakes placed vertically at equal distances all round and protruding into the gap between the cone and the crib surfaces. The extent to which the rubber blocks protrude into the milling chamber and their parallelism with the cone surface is adjusted by the hand wheels secured to the crib. Adjustment also is necessitated by the wearing out of the rubber blocks. The spindle is driven by an electric motor by means of pulleys and belts. It revolves on the ball bearings and rests on a thrust block. On the spindle shaft, is mounted a pinion which drives the crown wheel supported by a set of rollers. This will scavenge bran coming out of the milling chamber.

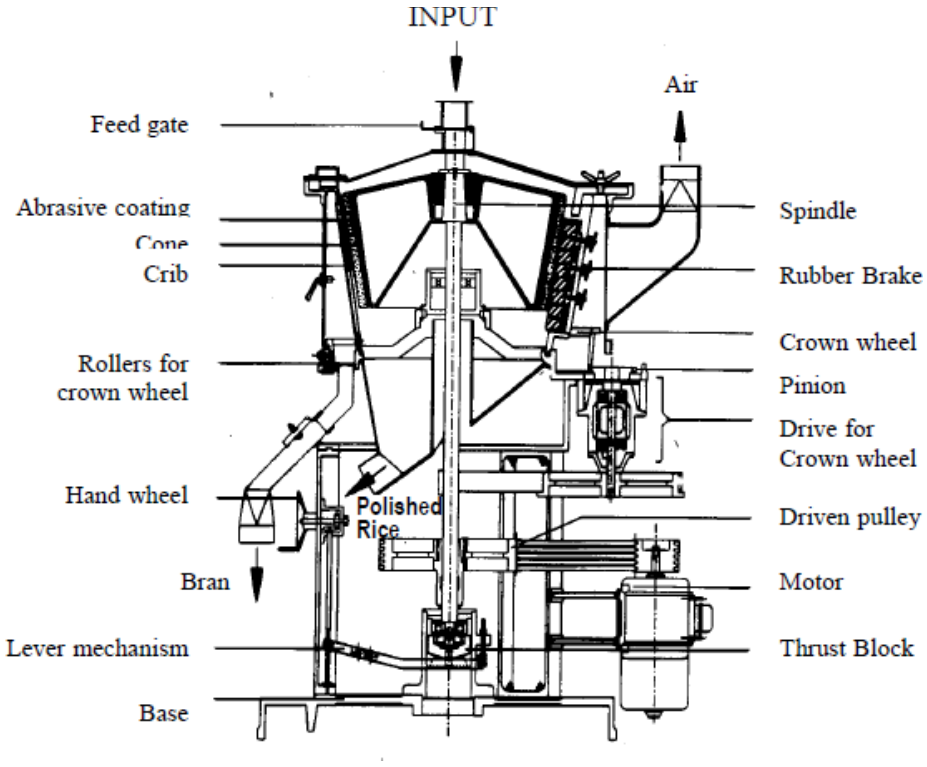


Fig 21. Constructional details of Cone Polisher

The diameter, cone height and rpm are adjusted such that the force resulting from centrifugal force and gravity causes the grain to spiral down for scouring of the rice all around.

Generally, a series of cones are used to polish rice in stages to get the required degree of milling. These whitening cones are a common feature in the plants meant for milling parboiled paddy, though they are also used for milling raw paddy.

Vertical polisher:

Vertical polishers are divided into two groups according to the direction of flow. The first has rice grains moving downward. The second has rice grains being pushed upward.

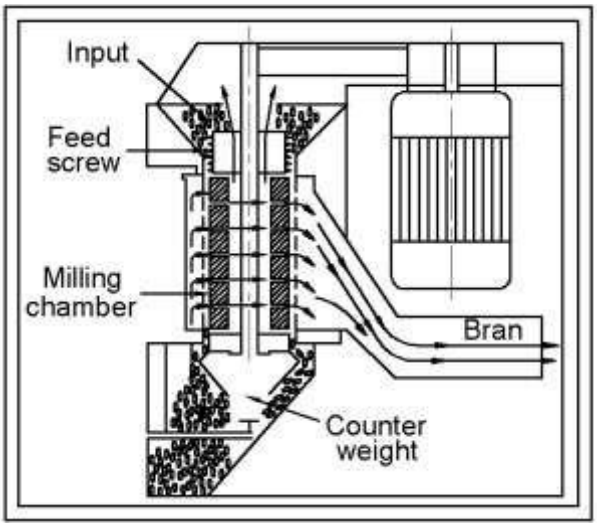


Fig. 24 Vertical friction Polisher

In the polisher that pushes the rice grains upward, the rice grains are conveyed by a horizontal conveying screw and then pushed up with a screw roll in the abrasive section. In the vertical down flow type machines rice flows down by gravity. They are then polished by a cylindrical emery grindstone. The pressure on the grain is controlled by hanging different weights on the discharge gate. The grindstone (abrasive cylinder) is formed in the same way as for the horizontal abrasive mill. Air is sucked through the mill stock as it is polished. This prevents heating, reduces breakage, and keeps dust out of the mill.

Although there are large differences in their constructional features, the basic polishing method is the same as that used in the horizontal mill.

Horizontal type Abrasive polisher:

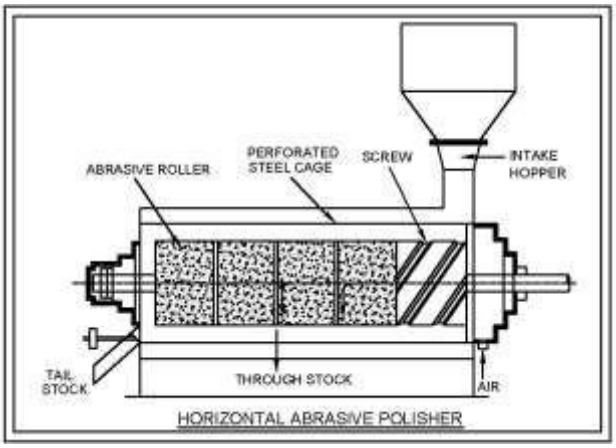


Fig. 23 Horizontal Polisher

This consists of an abrasive cylinder/discs attached to a steel shaft rotating in a perforated cylindrical, metallic screen mounted horizontally. These polishers are also called primary polishers.

Brown rice fed into the system passes through the clearance between silicon carbide abrasive roller and the perforated steel cylinder towards the discharge end. As the grain passes through the space between the roll and the perforated screen, bran layers are peeled off from the grain.

Bran passes out through the screen and polished rice is discharged through the outlet.

The pressure on the grain is controlled by hanging different weights on the discharge gate. Resistance pieces attached to the perforated steel cylinder help to alter the flow rate and the grain density inside the milling chamber. Angle of the resistance pieces can be adjusted from outside even when the machine is in operation. The angle of resistance pieces against the abrasive rotor can be adjusted from 0 to 90 degrees. By changing the angle, rice movement in the whitening chamber and the resistance to grain flow can be altered.

Friction type polishers:

Horizontal friction polisher:

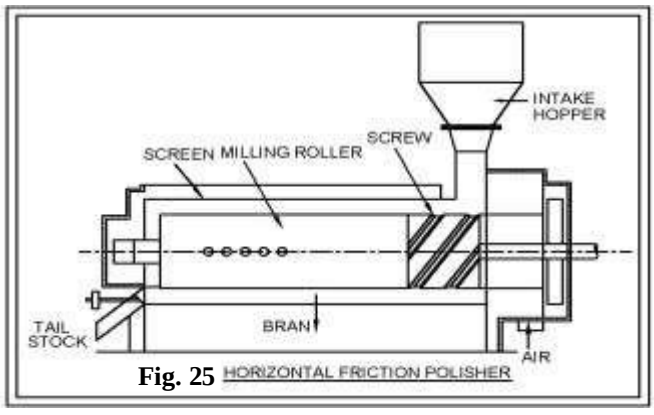


Fig. 25 HORIZONTAL FRICTION POLISHER

The machine consists of a cylindrical steel roller rotating inside a hexagonal perforated screen. The cylinder has a long slit along its length and a hollow shaft for passing air. The clearance between the screen and cylinder is adjustable by opening or closing the screen. The pressure on the rice is further controlled by hanging weights on the discharge gate. A centrifugal blower through the hollow shaft and long slit of the cylinder. The air helps in separating the bran and removing the heat generated by the friction between rice and rice. The machine consists of a cylindrical steel roller rotating inside perforated screen. Semi-polished rice is fed into the milling chamber by the feed conveyor. Pressure inside the milling chamber (degree

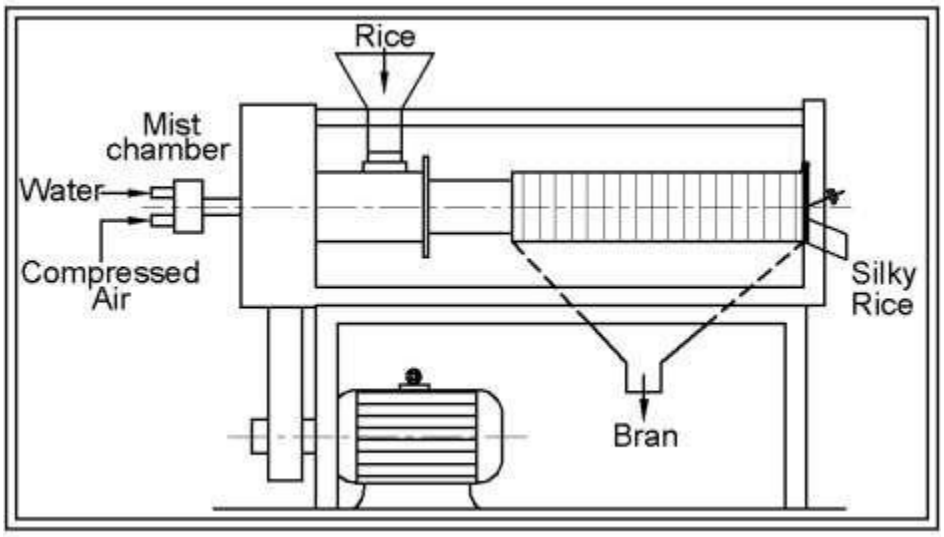
of milling) is adjusted by putting loads at the outlet gate. Rice passes from bottom to top and is whitened by friction. Polished rice is discharged at the outlet. Bran removed is sucked through as it comes out. This high pressure air lowers the operating temperature at the milling chamber, makes removal of bran easier and reduces breakage.

Generally, the abrasive polishers are used as primary polishers and the friction polishers as the final polishers. The percentage of bran removed in the primary polishers is the greatest. Adhering bran particles are removed in the friction polishers.

Operation: Stepwise polishing in several polishers gives minimum breakage during milling, thus increasing total and head rice recovery. Keeping the abrasive roller uniform and in balance reduces grain breakage. When parboiled rice is milled, the bran tends to stick to the screens. In this case, the quantity of aspirated air is increased to overcome choking of the screens. The bran coming out of the polisher should be checked often to make sure that it does not contain broken rice, not to speak of head rice.

Recently, polishing units which have a combination of both abrasive and friction types in series, in a single machine, have been developed. They eliminate the use of intermediate elevator and surge bins and are more compact in structure.

Water jet polisher:



There is an increasing demand for fully polished, white, smooth, shining, glossy, silky rice. Although an inferior appearance may not reduce the nutritional or functional value of rice, consumer will be pleased and satisfied with a product that looks delicious.

Fig. 26 Water Jet Polisher

A Water mist polisher/ silky rice polisher was developed to meet this demand. Polishing unit is very similar to the friction type polisher. Main differences are in the milling action. Milling

chamber is elongated to almost twice the length of the friction units. Water and compressed air tubing are fitted to the hollow shaft. Milled or semi-milled rice is fed into machine. Rice is forced to move quickly in a circular motion around its feeding axle, rubbing against each other at high pressure and very high speed. As rice grain is rubbing against each other at very high speed so breakage is minimal. Due to high pressure and friction, grain temperature increase rapidly. Surface of rice will gelatinize. During polishing, part of rice surface rubbed against each other so some surface with dust and bran is rub off, hence rice is cleaner. After rice surface is gelatinized, it will be a thin layer of shiny dried gelatinized starch. This thin layer has smooth and glossy touch. So rice has shiny appearance.

Bran separation:

In conventional mills, a reciprocating sieve is used for separation of brokens from bran. In the modern mills a pneumatic bran separator is adapted. A pneumatic bran separator separates rice germs and brokens from bran and also conveys the bran pneumatically (i.e., by air). It consists of a powerful centrifugal fan which aspirates the bran from the polisher and delivers it to a cyclone. A blower and an auxiliary cyclone aspirate the bran from the outlet of the main cyclone. Thus fine bran is separated from coarse materials (germs and brokens).

Grading

After polishing operation, the milled rice contains, in addition to 'whole grains', broken grains of different sizes as well as some bran and dust. Separation of these materials, termed 'grading', must now be done. Bran and dust particles are removed by aspiration. Brokens may be separated either by a `sifter' or a 'Plansifter' or by a 'Trieur'. In sifters, grading is based on differences in breadth or thickness of brokens and wholes. Trieurs work on the differences in the length of grains.

Plansifter:

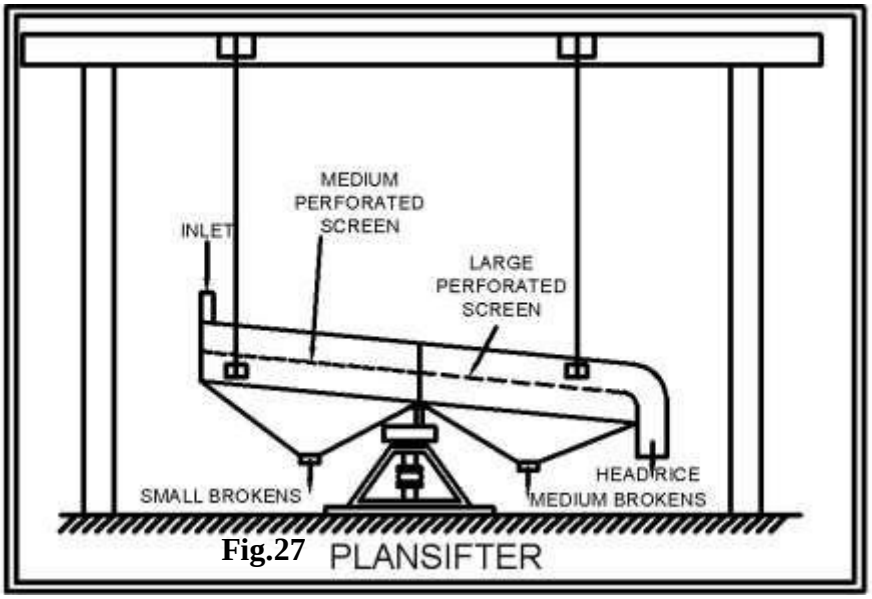


Fig.27 PLANSIFTER

It is a single or double decked sieve which is given a swinging (gyrating) motion produced by an eccentric. It consists of two sheets of different perforations (first small and then large) to separate two grades of brokens from the polished rice. The grain moves across the swinging sieve in a continuous spiral path.

A plansifter (short for planetary sifter) being of sieve type, cannot separate all broken grains from head rice. Big brokens remain along with head rice, while small brokens (less than half the size) are removed. Sieves of the grader should be kept free from clogging for maximum removal of brokens.

Trieur cylinder:

This is a slightly inclined rotating cylinder having indentations, like small pockets or cockles, all along its inner body. Rice from the polishers is fed to the raised end of the cylinder. As the rice passes along the slowly rotating cylinder, the broken grains sit nicely in the pockets and are therefore picket up by the rotating cylinder. But as the cylinder rotates upward, these broken grains finally fall out at a higher point and are caught by a collector trough fixed inside the cylinder and are discharged separately. A screw conveyor is used for this purpose of discharging broken grains. Whole grains, being too long, cannot sit into the small pockets. Hence, they move down the cylinder undisturbed as it rotates. Whole and broken grains are thus separated into two streams. By adjusting the size of the indentations and the position of the trough, broken rice of different sizes can be separated according to their length. In commercial practice multiple cylinders of different indentations are employed for separation. Broken rice is later combined with whole rice in specific proportions to suit market requirements. Basmati rice is usually exported/marketed as 100% whole length rice.

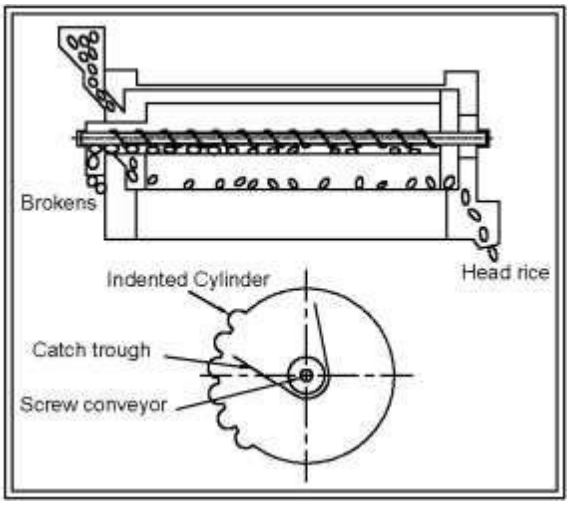


Fig.28 Trieur Cylinder

Colour sorter:

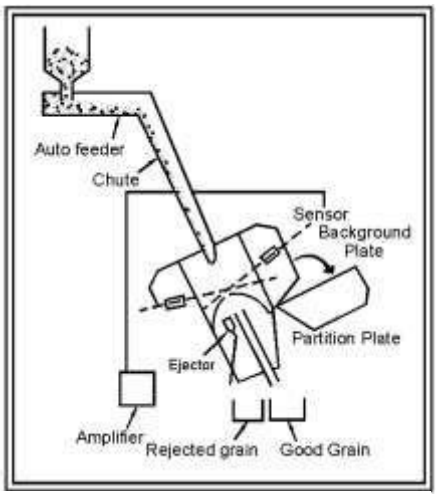


Fig.29 Colour sorter

The colour sorter is a photoelectric particle separator. The chute – type colour sorter that is now in wide use was first developed in the United Kingdom. Toward the end of the 1880s, it was discovered that the electrical conductivity of selenium oxide varies with the amount of light present. This fact provided the basis for the colour sorter.

A solenoid air valve (ejector) is connected electrically to a sensor that distinguishes, on the basis of reflected light, the background from the rice grains falling from a conduit haped chute; the ejector discharges any grains that are discoloured. Sorter efficiency and accuracy have been significantly improved by taking advantage of the progress in the electronic circuits.

Rice grains are fed in a channel to fall one grain at a time. Each grain is then compared with the set standard. Should there be any deviation in the colour of the rice grain from the set colour, then the ejector blows a jet of air thus pushing the discoloured rice grain from the mass. It is possible to set the colour to any desired shade, thus making it possible to colour sort the rice grain to a uniform hue.

We have so far discussed different operations and machinery involved in the process of rice milling. A modern rice mill would have all the unit operation machinery working in sequence. From the days of manual pounding of paddy to the hullers and modern rice mills and the state of the art ultra-modern PLC/ computer controlled rice mills, the progress witnessed in the field of rice milling is phenomenal. With this progress, there is a continuous improvement both in the milling yield and quality of rice produced by the mills. This also has contributed in upgrading the quality of oil-rich rice bran. This has pushed up the production of good quality, edible grade rice bran oil contributing much to the oil pool. Many of the mills also use paddy husk as a source of thermal and electrical energy and are operating as self-sufficient, zero-energy plants.

Milling of Pulses

Introduction:

Pulses are part of the legumes, a family of plants that have the unique characteristic of hosting symbiotic bacteria that fix atmospheric nitrogen in the plant roots. This not only reduces fertilizer requirements, but also improves soil structure. Pulses provide green pods for vegetables and nutritious fodder for cattle because they are rich in protein and in the essential amino acid lysine. Dry pulses are also a major food staple of populations in India, the Middle East, Africa, and South America.

Globally, pulses occupied an area of about 81.02 million hectares contributing 73.21million tonnes of production to the world (2013) food basket. India shared 34.77 per cent of area and 25.01 percent of global pulses production. Thus, India (2013) is the largest producer of pulses in the World, in an area of about 28.17 million hectares, with annual production of 18.31 million tonnes as shown in the figure-1. In India, according to 2014-15 statistics, Karnataka (8.10%) is one of the leading states in India, ranking fifth after Madhya Pradesh (28.14%), Maharashtra (11.96), Rajasthan (11.37%) and Uttar Pradesh (8.38%) as shown in Table-1.

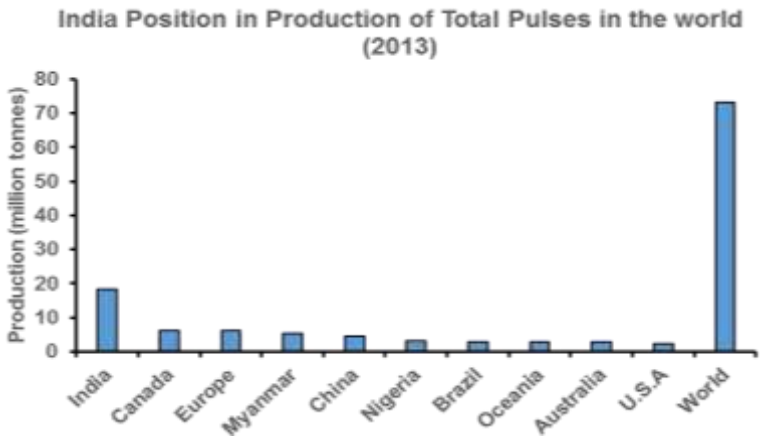


Figure 1: India Position in Production of Total Pulses in the World (2013)

In India, Chickpea, Pigeon pea, Green gram, Field pea, Cowpea, Urd bean, French bean, Moth bean, and Lentil are the most grown pulses. Further, being a source of protein, pulses are also significant for sustainable agriculture as they improve the physical, chemical, and biological properties of the soil and serves as miniature nitrogen factories. Pulses also have an innate quality to trap moisture from the lower strata of the soil; hence, they are significantly known to be famine tolerant and suitable in a rain-fed environment. Pulses are also essential for nourishing soil health and sustainability in different cropping systems. Being a restorer of soil fertility, pulses have a distinctive position in cropping

systems and dry land rain fed agriculture. The higher leaf drop of that cultivation of pulses saves nitrogen to the tune of 30-40 kg/ha, for successive cereal crops and also increase soil health by ensuring environmental security. Pulses in India have a distinct role in meeting the protein requirement of mainly vegetarian population. These crops have added advantage for sustainable agriculture, because of their soil enriching abilities and various use as feed and fodder. Early maturing cultivars fit well in different cropping systems.

Table 1: Top ten states in total production of pulses in India (2014-15)

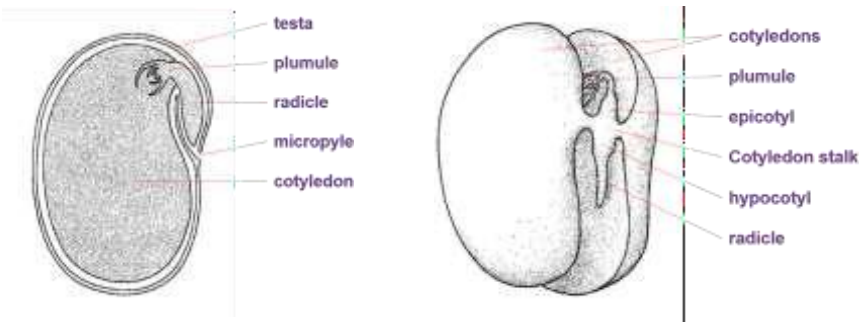
ank	State	**Area (million hectares)**	**Production (million tonnes)**
1	Madhya Pradesh	55.11	4.82
2	Maharashtra	34.09	2.05
3	Rajasthan	33.62	1.95
4	Uttar Pradesh	23.50	1.43
	Karnataka	23.13	1.39
6	Andhra Pradesh	10.43	0.95
7	Tamil Nadu	88.39	0.75
8	Chhattisgarh	00.90	0.73
9	Jharkhand	00.59	0.59
10	Gujarat	00.59	0.57

Before cooking or other processing operations, it is often necessary to remove the fibrous seed coat (hull). In addition to reducing the fiber content, this improves the appearance, texture, quality, and palatability of the pulse and reduces the cooking time. Dehulled seeds are easily digested and efficiently utilized by the body.Pulse decortication and splitting are age – old technology that has been developed through the trial and error approach. This is the probable reason for non-uniformity in methods and machinery adopted by pulse processors in different parts of the world. Several research reports on the efficiency of some indigenous or mechanized dehulling systems studying the state of technology of pulse processing have been reported by many authors.

Physicochemical characteristics of pulses

The effectiveness of dehulling depends on the properties of the grain and type of machine used. The yield of desired and undesired products obtained from dehulling depends on the following grain parameters:

1. The type of grain and its properties
2. Bond strength between kernel and hull, strength of kernel, and strength of hull
3. Proportion of hull in the kernel
4. Grain size and uniformity
5. Moisture content of grain and difference in moisture content between hull and rest of the kernel
6. Extent of hydrothermal treatment given to the grain
7. Proportion of dehulled kernel in the grain
8. The ease of classification of dehulled kernels and hulls



Seed structure

Figure 2. Schematic views of lentil seed

All pulses have a similar structure, but differ in colour, shape, size and thickness of seed coat. Mature seeds have three major components: the seed coat, the cotyledons, and the embryo. Table 2 gives the approximate mass proportion of each component

Table 2: Mass proportion of components

	Seed coat	Cotyledon	Embryo
Chickpea (*Cicer arietinum* L)	15.0	84.0	1.0
Pea (*Pisum sativum*, L)	10.0	88.7	1.3
Lentil (*Lens culinaris*, Medik.)	8.0	90.0	2.0

The seed coat, or hull accounts for 7 – 15% of the whole seed mass. Cotyledons are about 85% of the seed mass, and the embryo constitutes the remaining 1 – 4%. The external structures of the seed are the testa (i.e., seed coat), hilum, micropyle, and raphe. The testa is the outer most part of the seed and covers almost all of the seed surface. The hilum is an oval scar on the seed coat where the seed was attached to the stalk. The micropyle is a small opening in the seed coat next to the hilum. The raphe is a ridge on the side of the hilum opposite the micropyle.

When the seed coat is removed from the grain, the remaining part is the embryonic structure. The embryonic structure consists of two cotyledons (or seed leaves) and a short axis above and below them. The two cotyledons are not physically attached to each other except at the axis and a weak protection provided by the seed coat. Thus the seed is unusually vulnerable to breakage. The outermost layer of the seed coat is the cuticle, and it can be smooth or rough. Both the micropyle and hilum have been related to the permeability of the testa and to water absorption.

Seed composition

Table 3 gives the approximate chemical and nutritional composition of pulses. Proteins, ether extract (including lipids), phosphorus, and iron are contained in the cotyledons for the most part. About 90 – 90% of crude fiber and 32 – 50% of calcium are concentrated in the seed coat. Although the embryo is rich in nutrients, it is the smallest part of the seed and holds only 3% of the total seed nutrients.

Table 3. General composition (%) of nutrients in pulses

Pulse	Protein	Starches	Sugar	Fiber	Lipids
Chickpea	14.9 – 29.6	60.6	3.5 – 9.0	25.6	5.0
Pea	21.2 – 32.9	56.6	5.3 – 8.7	8.7	1.2
Lentil	20.4 – 30.5	59.7	4.2 – 6.1	-	1.2

Starch is found mostly in the cotyledon, and the granules are embedded in a dense proteinaceous matrix. The average size of a starch granule is in the order of 25 – 28 m. Starch granules are a mixture of amylose and amylopectin. Pulses have a larger sugar content than cereals. The hull tightly envelopes the endosperm along its wrinkles and ridges and it is generally attached to a thin layer of the gum. The gum is reported to contain pentosans, hexosans, other polysaccharides, and uronic acids. The separation

and removal of the hull depends on the nature of the gum and its hydration properties.

Pulses are categorized in two groups based on their milling characteristics: (a) easy to mill (e.g., lentil, chickpea, pea), and (b) difficult to mill (e.g., pigeon pea, black gram, green gram, beans, cowpea). The bond between the husk and the endosperm is weak in easy – to – mill pulses, whereas they are held firmly together by the gummy layer in difficult – to – mill pulses.

Unit operations in pulse processing:

The sequence of operations in pulse processing is pre-milling treatment, dehusking or decortication, and splitting. Large variations exist in the steps followed in each operation.

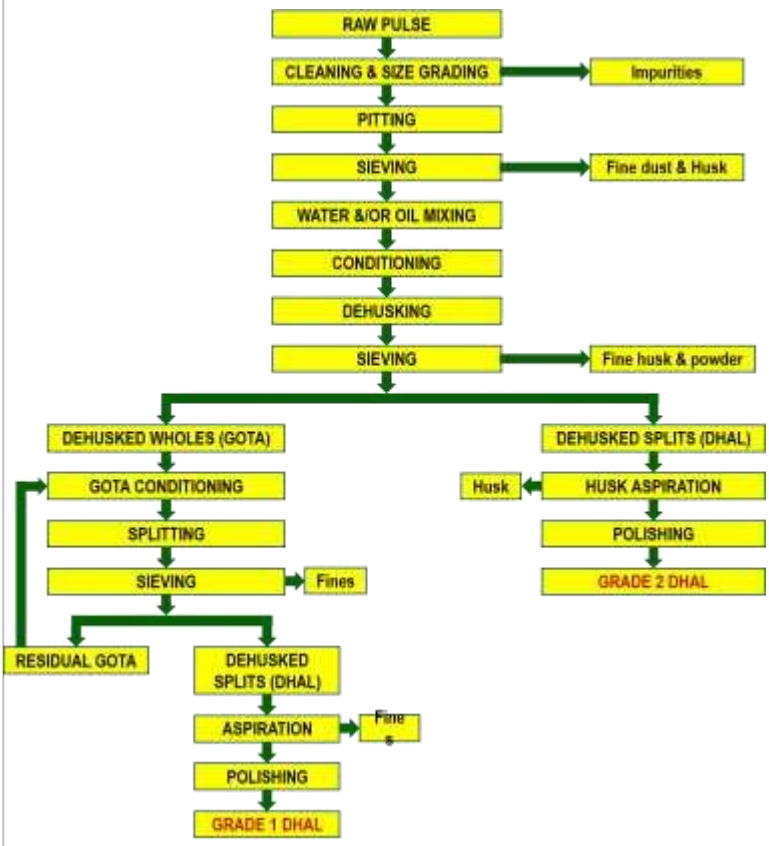


Figure 3. General flow chart for pulse milling process

In traditional operations, the dehulling is done either by the wet or dry method. In the wet method, the pulse is soaked in water for specific duration (depending on the pulse) before sun drying and milling. In the dry method, a small quantity of water or oil is applied onto the grain which has been previously scratched (or pitted) and conditioned (time is usually shorter). In the modern methods, high – temperature – short – time heating is used for conditioning the grain for loosening the husk. The general flow char for modern pulse processing is shown in Figure 3 above.

Milling methodologies:

Milling of pulses is practiced widely in Asia and Africa; it gives dehulled cotyledons with better appearance, texture, and cooking qualities. Pulse milling constitutes two major steps: loosening of the husk, followed by removal of loosened husk in suitable milling machinery.

The first step is commonly referred to as *pre-milling treatment*, whereas the second is referred to as *milling* or *dehulling*. The first step of loosening the husk is achieved either by a wet or dry method. In the wet method, the grains are soaked in water for a few hours, drained, left in heaps (usually overnight), and very commonly dried in the sun. in the dry method, grins are mixed with a small amount of oil, usually after scarification of the husk. This scarification of the husk is commonly called *pitting* and is done to facilitate the oil penetration between the husk and the cotyledons. Oil – treated grains are heaped overnight and then dried in the sun for 2 – 5 days, with intermittent water spraying and mixing. In both the pre-milling treatments, adherence of the husk to the cotyledon weakens and, consequently, its removal becomes easy.

The loosened seed coats of the pretreated pulses are removed in the subsequent operation of milling. For this purpose, different machines are used, depending on the type of pulse and scale of operation (Figure 4). Pulse milling is practiced at different levels: (a) home – scale, (b) cottage – scale, a motorized plate mill, under – runner disc sheller, horizontal flour mill, or hullers are used for milling; whereas emery – coated roller machines are used mainly in large – scale operations. Dry pre-milling treatment is preferred for large – scale operation, although it is time – consuming and laborious.

The oldest and most common method of milling pulses at the home scale is to pound them in a pestle and mortar or in a stone grinder after drying the grains in the sun or after mixing with a small amount of water. The husk is then winnowed of to obtain clean cotyledons. This method is still in vogue in the rural sector (home level) in a few African countries. The method of dehulling cowpeas in West Africa depends on the variety and the dish for which it is required. Cowpea grains are soaked in water for a few hours and the husk is rubbed off or lightly pounded and separated by washing when it is required to make cooked gravy or a deep – fried snack product, popularly known as Akara in Nigeria. Whenever cowpea flour is required, dehulling is accomplished by the dry method. The steeping process is alsopracticed in several Southeast Asian countries Generally wet – processing methods are practiced in India, particularly in the small – scale and in rural sectors for producing small quantities of dhals to meet the household requirements. Large – scale pulse mills in India, always prefer dry – processing methods. With the advent of the organized large – scale –milling systems in the last few decades, home – level operation and even small Pulses can be grouped in to two categories as “easy – to – mill”

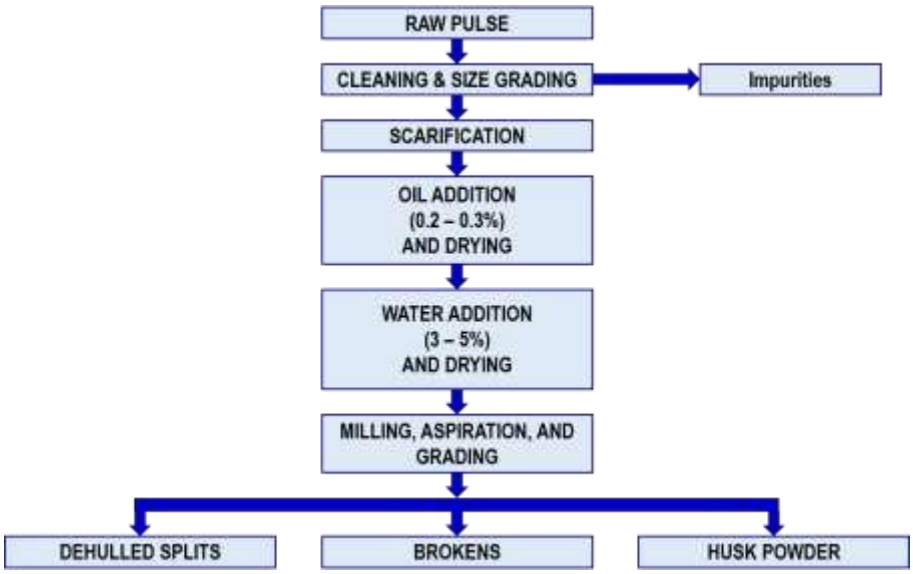


Figure 4. Flow chart for processing of pulses

and "difficult to – mill" depending on their milling characteristics. Because the seed coat (husk) of the pulses is tightly adhered to the cotyledons through a layer of gum, milling of pulses is different from that of milling of other grains such as paddy or wheat. Apart from this, the extent of husk adherence (i.e., the quantity and type of gum between the seed coat and cotyledons) determines whether the pulse is easy or difficult to mill. Generally easy – to – mill pulses such as chickpea, peas or lentils are processed in small – scale mills, whereas all difficult to – mill pulses such as red gram, green gram, black gram and beans are processed in large – scale pulse mills using dry pre-milling treatments. However, variations exist in pre-milling treatments and milling machines used for different pulses, as each pulse has a specific characteristic end use.

CSIR – CFTRI pulse processing machinery for the farm sector

Much of the processing of pulses is in the organized sector in large capacity mills. However, when farmers want the pulses grown by him for his own use, there is no small capacity mills suitable for the rural or farm sector. Recognizing this need, CSIR – CFTRI has developed a few mills suitable for this sector. The systems developed are described below

Mini Dhal Mill: This mill was the first of the mechanized machines developed by the Institute. The system comprises of a truncated cone coated with natural emery mounted on a shaft`. This assembly is rotating inside a stationary wire mesh cage. The shaft (along with the emery cone) can be moved vertically thus adjusting the clearance between the rotating emery cone and stationary wire mesh cage. Raw material (pulses) are fed to this machine with the required clearance so that the outer layers of seed coat are "scratched" or "pitted". Then, to these grains vegetable oil is added (0.3%) and allowed to temper for a while. During this period, the oil enters the space between the seed coat and cotyledon,thus loosening the gum between them. The grains are spread to dry in the sun for periods ranging from a day to a few days depending on the pulse being processed. After each day of drying, the grains are put into gunny bags and kept under a covered area. These grains are then passed through the same machine with a different clearance setting. During this second pass through the machine, the grains are stripped off husk and are split into two cotyledons. The mixture of husk and grains is aspirated to collect the husk separately. The grains fall due to gravity on a reciprocating grader having two sieves. The first sieve separates the smaller

brokens and the second sieve separates the split cotyledons (dhal). The grains passing over the last screen are unsplit and undehusked grains. These grains have not been split since they are smaller in size than the rest of the grains and have escaped through the gap between the emery cone and wire mesh cage. These grains are collected separately and milled at the end of the day with a different gap setting. This system is suitable for bold pulses like Pigeon pea, Bengalgram, Peas and Soya beans. The system has a capacity of 100 – 150 kg/h and works on a single motor of 1HP (single phase) rating. It is possible to obtain about 98% dehulling with yield of dhal being 76 – 78% containing around 1 – 2% brokens.

Figure 5. Mini dhal mill

Figure 6. Mini Versatile Dhal Mill

Mini Versatile Dhal Mill: An improved version of the Mini Dhal Mill was developed in order to cater to ALL pulses. The principle of operation of this mill is similar to the Mini Dhal Mill. A cyclone collection system has been added to facilitate collection of the husk. This system also has a capacity of 100 – 150 kg/h and requires two motors of 1HP each (single phase). The yield of products and by – products as similar to the Mini Dhal Mill described above. This system (shown in photograph beside) has a footprint of 2m x 4m. The system is easy to operate, maintain and repair. All spares are available in the country easily since indigenous components have been used.

Versatile Dhal Mill: In order to cater to a slightly higher demand, a system to process all pulses at 250 – 300kg/h was developed. This system requires 16HP three phase AC power supply. A space of 8m x 12m is required to house this system. The system consists of cleaning the raw material, scarifying in the emery coated cone, adding 0.3% oil, mixing well and tempering the grains, drying them in the sun. After drying as mentioned before, the grains are passed through the emery cone for dehusking and splitting. The products of milling are subject to aspiration to remove the husk and grading to separate brokens, split cotyledons (dhal) and any unsplit grains. The unsplit grains are collected and passed through the emery cone with a different gap setting. If required, the dhal can be polished by adding a little oil and turmeric, to give a better, marketable, appearance. The system delivers about 98% dehulling with 75 – 78% dhal and brokens of 2 – 3%. This system has minimum dust pollution, can process all pulses and is suitable for small scale processors or in community milling centres. Since transportation costs are reduced, good quality dhal at competitive price is obtained. The photograph of the system is as shown above.

The design drawings of the above systems are available on payment of license fee. Alternately, interested persons can purchase the equipment from licensees who have already taken the technology from CFTRI.

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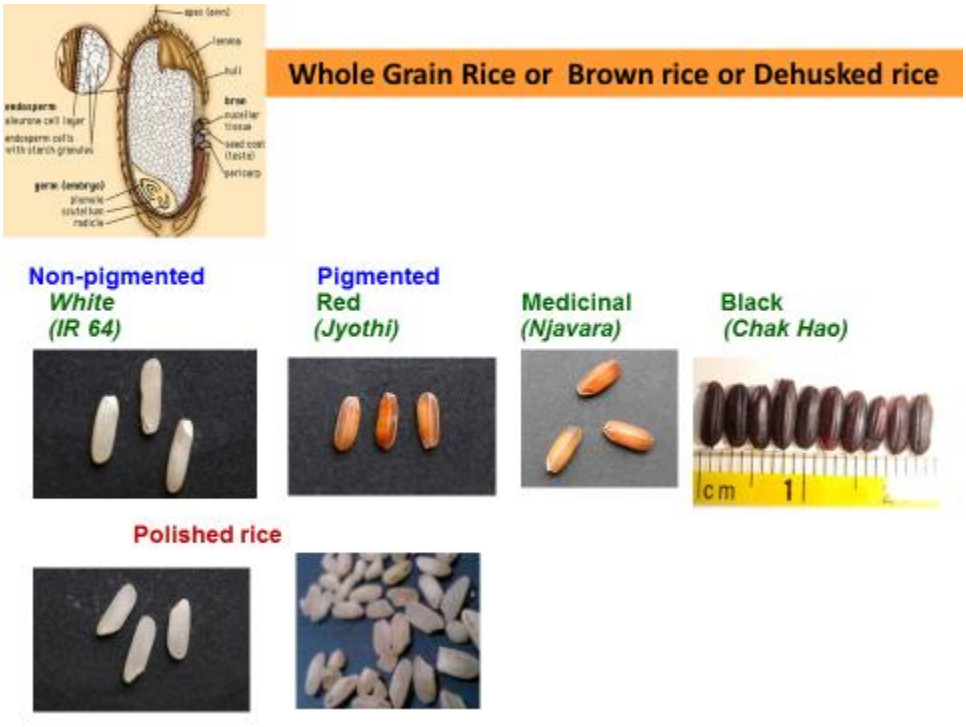
CHAPTER 5
Cereal-Based Snack Foods

NOVEL RICE PRODUCTS

Consumption of refined rice flour products is considered to increase the blood glucose load and because of this there is a demand for whole rice based products. Whole rice being high in fibre, minerals, vitamins, phytonutrients, etc., requires specialty processing, and research is going on to improve the functional and sensory qualities without affecting its nutritional qualities.

Rice diversity in India

In India hundreds of verities of rice are there. Verities based on bran colour and quality such as white, red, purple, black, medicinal, scented, etc., are some of the examples. Those are used in number of traditional preparations in different localities of India, and its commercialization potential is underutilized. These are generally used as husk removed form or whole rice/ brown rice with bran and germ. Whole rice is superior to polished rice due to the higher content of fibre, minerals, vitamins, antioxidants like oryzanol, vitamin E, polyphenols, etc. It is also reported to have anti-diabetic, cardioprotective and other health beneficial effects.



Problems in the utilization of whole grain rice and R & D for solutions

- Insect and microbial infestation- Fumigation and storage in PP bags.
- Lipase activity- Hydrothermal treatment of paddy.
- Oxidative destruction of fat - Spraying of herbal antioxidants; Vaccum packing
- Storage stability- Identification of packaging techniques suitable for long shelf life.
- Lack of awareness of public- Awareness creation on the health benefits and introduction of the item at the early stage of life .
- Absence of products based on brown rice- Propagation of partially polished rice; Brown rice flour blend, flakes, sweet snacks; soaked and germinated brown rice.
- Improvement in eating quality- Identification of varieties having satisfying flavour and consistency, and controlled processing.

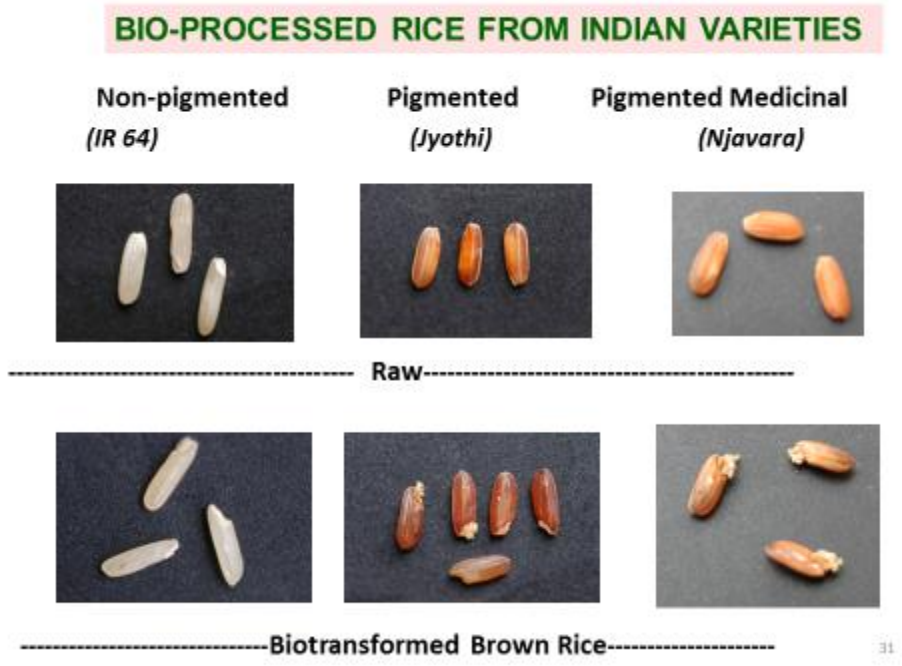
Whole rice based products

Optimally milled brown rice: Optimization of industrial scale hydrothermal treatment, continuous LSU based drying, abrasion polishing and packaging resulted in a process to obtain shelf stable (6-8 months) Optimally Polished Rice with maximum retention of nutrients and nutraceuticals, with acceptable sensory and cooking quality**.**

Germinated rice(Bioprocessed rice)

Germination, a traditional biotechnological method, improves textural, sensory and nutritional characteristics of brown rice. Number of biochemical alterations take place in it-Increase in hydrolytic enzymes like amylase, protease & lipase; increase in free sugar, oligosaccharides and soluble fibre; increase in free aminoacids and GABA which improves brain health; increase in phenolics like ferulic acids, etc. Improvement in digestibility and reduction in anti-nutritional factors.

However, germinated rice has low milling yield due to breakage, it can not be polished & poor cooking quality. So a bio-processed rice developed through technological interventions such as controlled germination, hydrothermal treatment, drying, de-vegetation and milling. This can be used as brown, partially polished or fully polished, and can be used in various rice preparations.

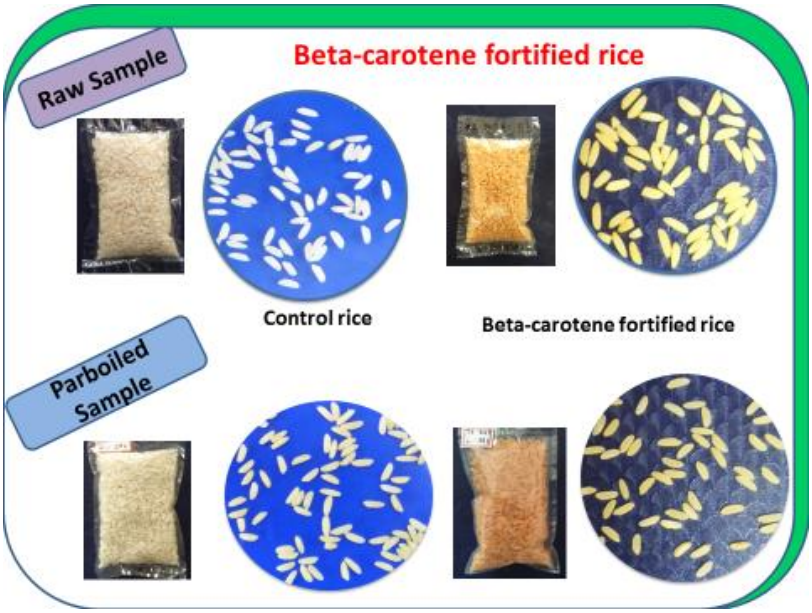


LOW Glycemic rice

Glycemic index: Indication of rise in blood glucose after consumption of a food. The AUC (area under curve) of two-hour blood glucose response of the test food divided by the AUC of the standard (glucose or white bread) and multiplied by 100. Both the standard and test food must contain an equal amount of available carbohydrate.

Glycemic index of rice:
High amylose (28%) (IR 8, Jaya, Mahsuri)- Low glycemic index (GI) – 64
Medium amylose (20%) (Basmati) - 83 GI
Low amylose (< 5%) (Japonica rice)- 93 GI
Parboiled rice- 40 GI
Rice with glycemic index of <55 is considered good for people with diabetes. Slow carbohydrate digestible rice can be developed by appropriate processing to reduce the digestibility of carbohydarte.

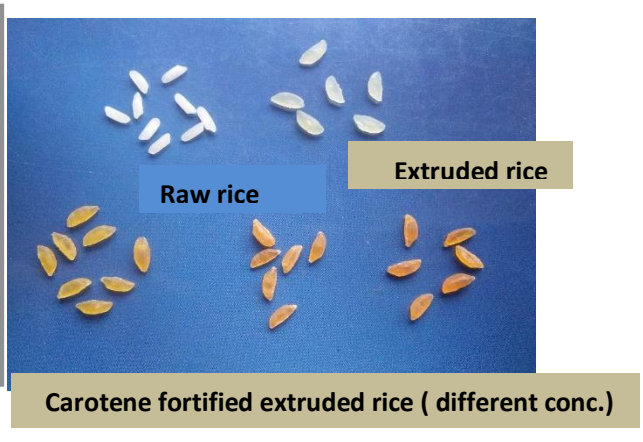
Micronutrient fortified rice
Micronutrient deficiency like iron, vitamin A, carotenoid, vitamin B, etc., are major nutritional problem in rice dependent countries. By different fortification techniques it is possible to enhance the micronutrient in rice. Trials have been carriedout to fortify rice with beta-carotene as well as iron with affection the rice quality charecterisitcs.



Extrusion technology in rice fortification: Hot extrusion is a versatile, continuous process and uniquely combines mixing of different components, thermal and mechanical heating, forming, and expanding.

It is not only a heating procedure but it is also a process with shear force and pressure that results in destruction and degradation of rice starch.Two types of extruders are there viz., single screw extruder and twin screw extruder. Extruded fortified rice development involves-preconditioning of rice flour, nutrient mix, additives with limited water; feeding of dough through a temperature regulated barrel where shear force is applied by a screw and extrudate is passed through a shaping die and cut by a cutter. Rice thus formed can be blended with normal rice at the ratio 10:100 to improve the nutritional content of rice.

SINGLE SCREW EXTRUDER



Products from Rice Flour

Different types of ready to eat or cook products have been developed from rice. Ready to eat products prepared from rice or paddy are rice flakes, expanded rice, poped rice, etc. Ready to cook rice based products are flours for the preparation of puttu, idiappam (string hopper), pathiri, appam (hopper),etc., and ada and noodles. In addition to these, ready mixes of rice and pulse mixtures like dosa, idli,etc., and ready to eat, deep fat fried rice and pulse flour based products like chakli, papad etc. are also there. Many of the rice flour based products can be prepared from broken rice also and thus result in value addition of broken rice.

Puttu

Traditional product of Kerala, prepared by mixing the flour with small quantity water and grated coconut followed by open steaming. It is made from low amylose and low gelatinization type coupled with low peak viscosity type rice flour. Product quality is improved by optimizing the grain hydration, particle size distribution and roasting. Two types of puttu are obtained from white rice and pounded red rice.

Idiappam (String hopper)/ Rice noodle

For the preparation of it a dough is made by mixing the flour with boiling water and then it is passed through chakli and steamed to cook. Flour for this need to be ground to very fine powder and toasted longer period to improve string formation and avoid stickiness in the product.

Pathiri (Rice chappathti)

It is prepared by making a dough with boiling water, spreading and cooking like conventional chapathi. Flour for this also is made to very fine powder, roasted optimally and sieved to eliminate coarse particles.

Appam(Hopper)

It is a fermented product popular in Kerala. Batter is made by mixing the rice flour with coconut, sugar and toddy , keeping overnight, and spreading in shallow utensil for cooking. Rice flour for this also need to be prepared from appropriate rice after pre-processing, grinding and toasting.

Rice ada

It is used for the preparation of payasam after boiling and draining. For ada preparation, pre-processed rice is made in to powder, slurry spread in trays in thin layer, steamed, dried and cut in to small pieces. Here also appropriate conditions are required to get clear, white and uniform size ada.

All these rice flour based ready to prepare products are available in market and there is great demand for these products in India and abroad for the preparation of traditional products which require extensive pre-processing steps. More R & D on physico-chemical nature of grain and processing conditions are required to improve the quality and develop more ready to cook traditional rice products.

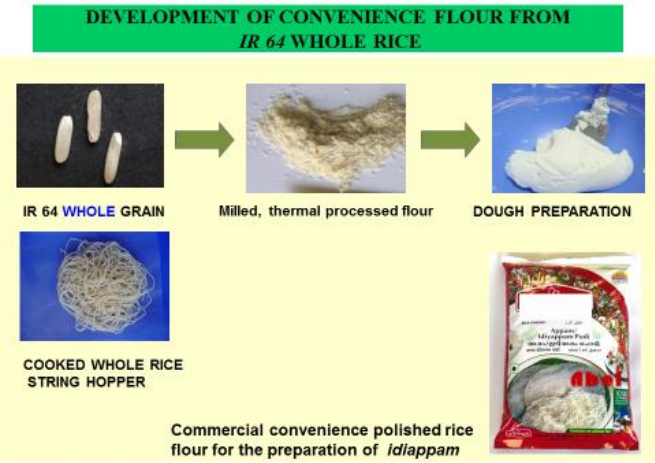
Factors Affecting the Rice Flour Quality

Quality of the rice flour and end product depends on number of factors like type of rice & quality; grain hydration period; drying duration; milling method; flour toasting temperature and time; particle size, etc. Because of these steps, great demand is there for ready to use flours for traditional products.

Convenience Whole rice flours

Even though polished rice flour is there, no convenience whole rice flour for traditional products are not there. Because of the drudgery in the preparation of traditional products there is a great demand for convenience, nutritious, healthy and safe products. So process considering the requirement to bring down the bran particle size, product forming quality, texture, stability, nutrient retention, is formulated.

However, not much ready to eat or instant rice flour products are there. One of the examples is Instant string hopper which is made through preparation of dough from appropriately pulverized flour with boiling water, cold extrusion, cooking, drying and packing.



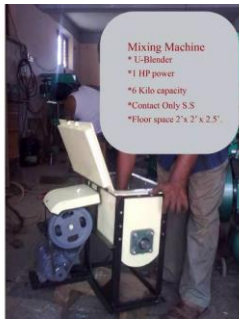
Technological requirements

Technological requirements in the development of ready to cook traditional products involve air drier, pulverizer, roaster, sifter and packing unit.

Air drier **Pulverizer** **Roaster** **SifterPacking**

New developments in rice flour products and wellness products

Because of the drudgery in the preparation of traditional products there is a great demand for convenience products. However, not much ready to eat or instant rice flour products are there. One of the examples is Instant string hopper(idiappam)/ noodle which is made through preparation of dough from appropriately pulverized whole rice flour with boiling water, cold extrusion, cooking, drying and packing. These can be made from white or red rice.



Commercial polished rice flour based instant *idiappam machineries*

Other red rice based instant products can also be made by using the related technology as well as fortification with vitamins, minerals and flavor which result in products with high content of health beneficial nutraceuticals like polyphenols, flavonoids, oryzanol, etc.

Convenience food products from unpolished red rice


Red rice


Ready to prepare multipurpose flour

Cooked products


Rice Roti (Pathiri)


String hopper (idiappam/noolappam)

Instant Product


Instant noodle/ String hopper


Instant Vermicelli


INSTANT BREAKFAST STRINGS (Iron Fortified)

•Convenience products prepared using brown broken/whole red rice is rich in protein, minerals, soluble, insoluble and total dietary fiber.

• Compared to polished rice flour content of nutraceuticals like polyphenols, flavonoids, oryzanol, etc., are high.

Bioprocessed wellness flours

By controled germination,hydrothermal treatment, milling and thermal treatment it is possible to obtain germinated brown rice flour or wellness rice flour with bioactive components. This can be used for preparation of traditional products and instant products with nutrients and nutraceuticals.

Bio-processed brown rice products

Wellness Rice Flour

Germinated red rice

Wellness rice flour

Appam

Pancake

Puttu

Wellness rice flour made from germinated whole red rice is rich in-

- GABA which improves the brain function and reduces the blood pressure;
- Gamma oryzanols having cholesterol lowering and anti-inflammatory property; Polyphenols having antioxidant activity.
- Superior to currently available refined rice flour with respect to minerals and fibre content.
- Wellness rice flour can be used for the preparation of traditional foods.

Instant Wellness Rice Flour

Instant wellness rice flour

Laddu

Instant germinated red rice based wellness flour can be used for the preparation of traditional sweets such as Laddu, Barfi etc., by mixing with milk, jiggery and coconut.

This flour is having GABA, oryzanol, polyphenols, fibre etc.

Can act as phytonutrient rich high calorie sweet for children.

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Chapter 6
Breakfast cereals

Introduction

Breakfast cereals are processed form of grains for human consumption. In general, breakfast cereals are grains processed into flour, cooked, mixed with other ingredients, dried, and shaped. However, grain can also be flaked, puffed, popped or extruded to make breakfast cereal. Most of the breakfast cereals are available either as ready-to-eat (RTE) or as hot cereals (HC) that requires cooking before consumption. RTE cereals are produced by a series of operations like cooking, shape forming, and drying. Corn flakes are the most popular in the R-T-E segment, whereas the major HC are rolled oats in various forms, farina and other wheat and corn fractions. Apart from processing, breakfast cereals are fortified with vitamins, minerals, and other nutritional additives in order to enhance its nutritional value.

Technologies for processing of breakfast cereals

1. Flaking

Flaking is a process to produce flakes from any cereal, the most popular being corn flakes cereal. It is one of the oldest technologies for processing of breakfast cereals. The first flaked breakfast cereal was created by Dr. John Harvey Kellogg in 1894 for the patients of the Battle Creek Sanitarium in Michigan where he was superintendent. The breakfast cereal proved popular among the patients and the Kellogg Company was set up to produce corn flakes for a wider public. A patent for the process was granted in 1896.

In case of corn flakes, the shape and size of the cob influences the flake quality. Since a cylindrical cob has more number of large flat grains, are best suited for dry milling to obtain grits of low fat, low fibre to yield high quality flakes with enhanced shelf-life. Conical cobs have lesser number of flat grains and more number of round grains that resist from being split during milling affecting the flake quality.

Another popular cereal flake available in market is oat flakes. Unique properties of oats such as, distinctively non-connected hull and endosperm, high fat content, high soluble dietary fibre, etc. make its milling different from other cereal grains. Oat's hull consists maily of cellulose,

hemicelluloses and lignin. Within the hull is the groat, which comprises 68-72 % of the kernel. Most commonly oats are processed as a whole grain because it's softer groat than other grain such as wheat, and thus cannot be easily converted into separate germ, endosperm and bran fractions.

Nutritionally better grains like millets and pseudo cereals can also be fabricated as flakes. For example, sorghum flakes rich in resistant starch, which may enhances dietary fiber content can be used in the dietary management of diabetics.

Process parameters like conditioning, cooking, drying and flaking can be controlled to produce better quality flakes. The thickness of the flakes can be adjusted to customize snack for obese and calorie conscious people. Further, crispiness of the flakes can be increased by toasting high moisture flake.

Processing

i. The milling process removes the corn kernels from the cobs and turns them into flaking sized 'grits'.
ii. The corn grits are cooked for an hour in steam pressure cookers, at temperatures exceeding 100°C.
iii. During cooking additional water is incorporated in the form of steam which condenses and increases water content to 30-35%.
iv. Then the hot grits are transported from the cookers to large driers where they are dried for several hours.
v. The dried grits are squeezed and rolled into flat flakes.
vi. The flakes are then tumble toasted in huge cylindrical ovens at 600°C.
vii. The toasted flakes are then coated with flavoring materials and packed.

2. Extrusion

Extrusion is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate. The extruder consists of a large, rotating screw tightly fitting within a

stationary barrel, at the end of which is the die. Extrusion can also used for making intermediate products for further processing. For example, the extrudate after extrusion can also be flaked to obtain a R-T-E or cook product.

Extrusion is of two types- hot and cold extrusion. Food products manufactured using either type of extrusion usually has high starch content. The cold extruded breakfast products are vermicelli, noodles, pasta, etc. The hot extruded products are usually R-T-E snacks.

Extruders are composed of five main parts:

(i) Pre-conditioning system;
(ii) Feeding system;
(iii) Screw or worm;
(iv) Barrel;
(v) Die and the cutting mechanism.

(i) Pre-conditioning: Pre-conditioning is done with steam or water and mixed manually. It favors uniform particle hydration, reduces retention times within the extruder and increases throughput.

(ii) **Feeding system:** Feeding of raw material into extruder should be constant and non-interrupted for an efficient and uniform functioning of the extrusion process.

(iii) **Screw:** Screw conveys material into the extruder barrel, shearing and ensures final product quality.

(iv) **Barrel or sleeves:** It is divided into feeding, kneading and sleeves. They are often jacketed to permit circulating of steam or superheated oil for heating or water or air for cooling, thus enabling the precise adjustment of the temperature in the various zones of the extruder.

(v) **Die and Cutting mechanism:** The die presents two main functions: (1) give shape to the final product, and (2) promote resistance to material flow within the extruder causing an increase in internal pressure. The die can present in various designs and number of orifices. The cutting mechanism must permit obtaining final products with uniform size. Product size is determined by the rotation speed of the cutting blades.

3. Popping

Popping is a high-temperature short-time process utilizing the entire grain including the outermost bran layer & germ. It is a cost effective process to obtain a ready-to-eat product. Most popular popped product is popcorn. For popcorn, a special variety of corn is used. Some wild types will pop, but the cultivated strain is *Zea mays* Everta, which is a special kind of flint corn. Popcorn varieties are broadly categorized by the shape of the kernels, the color of the kernels, or the shape of the popped corn. While the kernels may come in a variety of colors, the popped corn is always off-yellow or white as it is only the hull (or pericarp) that is colored. "Rice" type popcorn has a long kernel pointed at both ends; "pearl" type kernels are rounded at the top. Commercial popcorn production has moved mostly to pearl types. Historically, pearl popcorn were usually yellow and rice popcorn usually white. Today both shapes are available in both colors, as well as others including black, red, and variegated. Commercial production is dominated by white and yellow.

The unique thing about the pop-corn kernel is that it has moisture locked inside it. When heated, this water turns into pressurized steam, which expands and pushes outward against the walls of the kernel. The pressure continues to increase until the breaking point of the hull is reached: a pressure of about 135 psi (930 kPa) and a temperature of 180 °C (356 °F). The hull ruptures rapidly, causing a sudden drop in pressure inside the kernel and a corresponding rapid expansion of the steam, which expands the starch and proteins of the endosperm into airy foam. As the foam rapidly cools, the starch and protein polymers set into the familiar crispy puff. Under these conditions, the starch inside the kernel gelatinizes, softens, and becomes pliable.

There are various techniques for popping corn including small home appliances to large-scale commercial popcorn machines. The home appliances for popping corn require minimally

processed popping corn. However, the history of larger-scale commercial popcorn machine goes back to the invention by Charles Cretors in the late 19th century. Cretors successfully introduced his invention at the Columbian Exposition in 1893. At this same world's fair, F.W. Rueckheim introduced a molasses-flavored "Candied Popcorn", the first caramel corn; his brother, Louis, slightly altered the recipe and introduced it as Cracker Jack popcorn in 1896.

Expansion and yield

Producers and sellers of popcorn consider two major factors in evaluating the quality of popcorn: what percentage of the kernels will pop, and how much each popped kernel expands. Expansion is an important factor to both the consumer and vendor. For the consumer, larger pieces of popcorn tend to be more tender and are associated with higher quality. For the grower, distributor, and vendor, expansion is closely correlated with profit: vendors such as theaters buy popcorn by weight and sell it by volume. For both these reasons, higher-expansion popcorn fetches a higher profit per unit weight.

Factors affecting Expansion and yield during popping

1. **Heat-** If heated too quickly, the steam in the outer layers of the kernel can reach high pressures and rupture the hull before the starch in the center of the kernel can fully gelatinize, leading to partially popped kernels with hard centers. Heating too slowly leads to entirely unpopped kernels: the tip of the kernel, where it attached to the cob, is not entirely moisture-proof, and when heated slowly, the steam can leak out of the tip fast enough to keep the pressure from rising sufficiently to break the hull and cause the pop.

2. **Moisture-** Freshly harvested Popcorns has poor expansion and chewy pieces of popcorn due to its high moisture content. Kernels with high moisture content are also susceptible to mold when stored. For these reasons**,** dry the kernels until they reach the moisture level at which they expand the most (14–15%). If the kernels are over-dried, the expansion rate will suffer and the percentage of kernels that pop at all will decline. When the popcorn has finished popping, sometimes unpopped kernels remain, known as "old maids," the kernels don't pop because they do not have enough moisture to create enough steam for an explosion. Rehydrating prior to popping usually results in eliminating the unpopped kernels**.**

CFTRI NOVEL BREAKFAST FOODS

CFTRI have developed novel processes for the preparation of shelf-stable rotis from jowar, ragi etc., which are cost effective and can be stored at ambient conditions for one week or 1 month under refrigeration. Vermicelli from ragi and other millets, easily replace wheat and rice based traditional breakfast foods. These grains can also be flaked after appropriate processing, the flakes can also be converted to RTE products. The nutritive value and the various health benefits of the millets are being preferred by the health conscious population, hence these grains can be processed to prepare novel breakfast foods like multi- grain semolina, ready-to-eat breakfast cereals, noodles, instant porridge etc. Ready-to-eat puffed/expanded products from some of these grains can be attractive and healthy alternative can be used as ready-to-eat breakfast foods.

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Chapter-7

PACKAGING ASPECTS OF RICE, WHEAT, MILLED PRODUCTS AND SUGAR

Food grains are the rich source of life sustaining nutrients. Cereals/flours are good carbohydrate sources. In addition they provide protein fat, vitamin, oils minerals etc. They are the dietary staples providing the required calorie for more than 95% of India's population. Among them rice is the predominant Cereal grain followed by wheat, maize, millet and sorghum etc. cereals are annual crop but the consumption is continuous. Losses due to pilferage, insect and rodent attack and microbial spoilage may occur during storage. So a proper and safe storage method needs to be provided till it is consumed. A proper storage will be satisfied with proper and suitable packaging materials. Cereals in general are characterized by good stability, moderate density and low cost. Even though cereals have good stability, they are effected by high humidity, physiological factors such as respiration and heating in grains, biological factors like insects, pests, rodents and microorganisms and to some extent by oxygen. Flours are more sensitive for humidity and biological deteriorations than whole grains. All these factors cause qualitative and quantitative changes. As such proper packaging and storage methods are essential for good storage stability.

After cereals and pulses sugar is an important commodity, which is stored in bulk and sold at retail throughout the year. The type of spoilage and hence the packaging requirement varies according to the type of sugar. White cane sugar which is more popular in India is crystallized enough not to absorb water under normal storage conditions. But at high relative humidities it picks up moisture rapidly. To protect them from pilferage and spillage and insects like ant a proper packaging and storage methods are required for white sugar.

Nature and deteriorative characteristics of cereals/flours and sugar

In order to design functional and economical package for any food product, the knowledge of its deteriorative characteristics on storage and the cause of deteriorations are essential. Cereal grains/flours during storage are effected by the following factors mutually working with each other in causing deteriorations.

1. Physical factors like temperature and humidity
2. Chemical factors like moisture and oxygen
3. Physiological factors like respiration and heating
4. Biological factors Insects and pests, microorganisms, rodents and birds

Moisture is the most important one among the factors related to rate of deterioration. The relationship between moisture content and relative humidity data (table-1) provide a lot of information for package design

An equilibrium relative humidity of more than 70% can lead to mould growth in grains and flours. In whole grains heating due to increased respiration rate may result in insect and/or fungal activity. Higher the temperature, lower will be the equilibrium moisture content. Hence, for better storage stability of grains, the moisture should be about 11 – 12 % and 10-11% for flours at the time of packaging. If the moisture content is very close or above the critical level, diurnal changes in temperature causes mould growth due to moisture condensation on the surface. Insects and mites also depend on grain moisture for their life. The optimum level of moisture for most of the insects was found between 11 to 16% in grains. 14% is the lowest moisture level, which permits fungal invasion in most of the cereals. Apart from controlling moisture, lowering of temperature and restricting Oxygen supply also inhibits insect growth. Apart from these, varietal differences, the degree of maturity, methods of handling and transport, the number of broken/cracked kernels also effects the storage stability.

Sugar crystals are stable over a broad band of relative humidity. Its moisture content generally lies between 0.02 to 0.04%. But once it is exposed to 86% RH and above it suddenly picks up moisture and turns watery. Hence sugar is effected by moisture above 85% RH only. Above this it picks up moisture and when RH comes below due to changes in either temperature or variations in atmosphere, it dries out and crystals agglomerate themselves together. It is also susceptible to attack by insects like ant.

Packaging requirements of grains/flours and sugar

To retard the above deteriorations in the products a functional packaging

1. Should have the ability to protect the contents form spoilage and spillage
2. Should offer protection against environmental conditions, (should be a good barrier for moisture).
3. Should prevent insect infestation and insect damage, (should have good insect resistant property)
4. Should offer protection against microorganisms, (should be oxygen barrier to prevent their growth)
5. Should possess necessary strength properties to withstand mechanical hazards during transportation and storage.
6. Should assist in selling by attractive graphics

7. Should be economical, easily available and disposable
8. Should conform to the food laws.

Current trends in packaging and storage of whole grains/ flours and sugar

In order to maintain the quality and quantity of cereal grains, many storage methods are being employed. Cereals are mostly stored loose in bulk, in a variety of containers or in sacks stacked in ware houses

The choice between these depends on the factors like:

1. Type and value of produce
2. Duration of storage
3. Climate
4. Transport system
5. Cost and availability of labour and sacks
6. Incidence of rodents and certain type of insects and infestation.

The advantages and disadvantages of bulk storage over sack storage are as follows:

Bulk	Sacks
1. Inflexible storage	Flexibility of storage
2. Mechanizable	Partly Mechanizable
3. Rapid handling	Slow handling
4. Little spillage	Considerable spillage
5. High Capital cost	Low capital cost
6. Low operating cost	High operating cost
7.Low Rodent loss potential	High rodent loss potential
8. Little protection against reinfestation	Reinfestation occurs

Bulk Storage of grains

Traditionally the grains are bulk stored in Bukhari type, Kothar type or Morai type rural food structures constructed on elevated platforms which are supported on timber posts or brick/stone masonry pillars. They are constructed using bamboo/bamboo split, timber, reeds, red gram stems plastered with mud. Underground rural food grain structures are also constructed and they are made water proof using bitumen. Modern methods of grain storage are an elaboration of traditional method but are constructed using modern materials. The bulk bins are constructed with concrete, steel or glass lined steel. A system to transport grains/flours and by-products to the bins and a system of feeders and conveyers to move flour and mill feed to packaging bins, bulk rail road cars and bulk trucks and to transfer them from one bin to another are in practice. Airtight bulk storage silos keeps the grain free from insects, rodents and other pests. Here insects are killed by oxygen depletion and not by carbon-di-oxide accumulation. Metal silos up to 200 tons capacity are commonly used. Flexible bag silos, of butyl rubber or

PVC supported in metal mesh cases are available. But they need to be protected by rodents. Some times to overcome the changes in pressure during storage resulting from high production of carbon-di-oxide, a pressure release valve is fitted at the top of the silo. The silos are well sealed to provide an hermetic structure and are also suitable for gas fumigation. The shelf life of the grain stored in silos depend largely on moisture content of the grain and the storage atmosphere.

Bag storage of grain/Flours/Sugar in warehouses.

This is the most common method used world wide for grain and sugar storage. Grains and sugar are packed in Jute /paper/rice straw/burlap/HDPE or PP woven bags and stored in a variety of types of buildings constructed with stone, local brick, corrugated iron, mud and wattle with or without plastered walls and cement or stone floor and corrugated iron or thatched roof. Such type of godowns is planned for the storage of 100 to 500 tons of grains.

Jute/ Hessian sacks

These are traditional bulk packages, for grains/flours and sugar which offer good handling properties. The flours and sugar require A- twill bags, which have a weave clearance of 1-2% only to prevent spillage. B-twill or D. W. bags having a weave clearance of 6-10% can be used for most of the cereals. But as such they cannot protect the products form moisture ingress. So sacked jute bags are covered with tarpaulin sheets. Their protective functions can be improved by inclusion of webs of paper, plastic and foil. These prevent sifting of the contents and provide water vapour barrier property.

Storage of grains in jute sacks

Plastic Woven sacks

Flat or circular woven plastic sacks made of PP or HDPE with suitable PE layer can be sued for cereals/flours and sugar. They offer good protection at high humidities economically. Up to 100kg product can be packed in them. The relative merits and demerits of Jute and HDPE/PP woven sacks are as in Table 2.

Multi wallpaper sacks

For flours and sugar below 86% RH, paper sacks made of 3 – 7 plies of kraft, union kraft or extensible kraft are generally used upto as bags to hold 50 kg capacity. Laminating them further with PE/PP and/or aluminum foil lined would further increase their utility.

The advantageous of bag storage over bulk storage of grains is, bags may be piled under any convenient shelter and can be transported and handled without special equipment. The main disadvantage is bags storage space and bagging become expensive particularly where manpower costs are high. Under water storage of grains in 60 kg unit packs packed in double plastic bags with nylon inner bag and nylon/Al. foil/ PE outer bag is found to retain original freshness of the product even after prolonged storage. The seeds protected under water found to have better germination capacity than stored by conventional methods. Carbon dioxide packaging is more effective than air. Low temperature storage in straw or gunny bags also yields better results.

Unit packages

Packaging is the key to the successful marketing for modern food products. It goes beyond eye appeal, convenience in size, shape and ease of opening. The product to be protected against infestation, contamination, entry of oxygen and moisture.

The main function of the unit packages for cereals flours and sugar is containment of a measured quantity. So the consumer knows how much he or she is buying and the merchant knows how much to charge quickly and easily for both the parties to the transaction. As the bulk density is high, the packaging material needs to have good impact strength and good tensile strength for working on FFS machines and good puncture resistance as some grains have sharp edges. Textile/Jute/ burlap bags are used for this purposes for above 10 kg unit packs. But as they are highly vulnerable to vermin infestation, plastic woven are being used for the purpose. Up to 10 kg unit packs both LDPE and LLDPE meet the requirements and blends of the two, with LLDPE being used for additional strength are most commonly used packaging material.

Rice packs in units of 1 to 25 kg

Unit packages for milled products

Retail packs of basmati rice in PET/LDPE laminates of 1 and 5 kg units

To protect the product from flavour loss and from development of oxidative rancidity, special varieties like Basmati rice, brown rice and flours need a flavour barrier packaging material. Hence reverse printed polyester laminated to LDPE for longer shelf-life and co extruded LD/LLD for shorter shelf-life is under usage. PET/LDPE laminate apart from protecting flavour loss and rancidity, retards insect infestation, prevents pick up of foreign odours and offers excellent printing. Anti oxidants like BHT has a better effect when rice is packed in an oxygen barrier film not otherwise Vacuum /CO_2 flush packaging also has beneficial effect in the extending shelf life of brown rice. Brown rice, which has 3 – 6 months shelf life in LDPE bags, will have about an year shelf life when vacuum packed in nylon based laminates. Vacuum or CO_2 flush packaging can control pests, insects without fumigation or usage of chemicals apart form offering protection from oxidative rancidity for any food grain. Vacuum packed bag in boxes are good for transportation also. More than 2 years shelf life can be expected for vacuum packed rice when stored under 17-30°C and 65-85% RH. But these oxygen barrier materials are expensive. Hence to protect the products from off flavours developed due to rancidity, perforated bags are being used to allow rancid odour to escape.

Insect infestation in grains and flours

Insect infestation is the major problem in grains and flours. They are prime targets of many predators like insects, pests, rodents, mites and undesirable micro organisms. Besides destroying a significant portion of food, they qualitatively affect the remaining part through excretion of toxic chemicals and contamination with excreta and insect fragments. Standard specify the maximum limit for these. Insect penetration can be controlled by using different packaging materials. Therefore initial insect contamination should be destroyed at the time of packing. The insect resistance of packaging materials for some common insects is presented in Table 3. Vacuum or CO_2 packaging can prevent the development of pests inside the bag. But the high barrier films required for them are expensive. Hence periodic treatment with permitted pesticides

only can prevent reinfestation or cross infestation. The grains are to be fumigated or irradiated or treated with microwave. The permeability of fumigants through different films and laminated are cited in Table 4. When used in the recommended dosages, the shelf life of grains will be extended for more than 6 months as against one month for the untreated product. These methods have been found as the most effective method in controlling pests in grains/flours.

Bags getting ready for fumigation. Recent trends

The recent trend emphasizes more on unit packages. The stress is on use of more decoration, transparency, simplification of package construction and production of packages by automatic means. As with these smaller packages preservation becomes more difficult and hence use of increased quantities of films and laminates for improved protection and increased shelf life will become popular. This will be expensive as more storage space and more packaging materials are required. Hence a unit package must be carefully designed and automatically packed for cost reduction.

Conclusion

The critical moisture for cereals and flours being less than14%, care should be taken that the moisture content of the products should be well below the critical moisture at the time of packaging when sold at places where RH is above 70%. Proper method like fumigation/irradiation to kill the insects if followed, insect infestation can be controlled. Sugar needs protection above 86% RH. For bulk storage of grain, metal silos can offer good air tight storage condition and is the most modern and scientific method and offers better shelf life than others. Low temperature storage is more effective for long-term storage for grains. Bag storage in warehouses is very common and storage method for grains and sugar. Jute/HDPE/PP woven sacks are being emphasized. Woven plastic sacks will register highest growth rate, if they are allowed to compete with jute sacks without restriction owing to their advantage. The unit

packages for sugar and flours are becoming popular. Pigmented 300 g LDPE, PET/PE are being good for the purpose.

So it can be concluded that packaging for cereals/flours and sugar is vital and necessary part of storage, handling, display and preservation in the present economy. But as these are essential commodities, packaging must accomplish all its functions at the lowest possible cost. As such ways of minimizing loss and keeping the grains for longer in economic suitable container is the need of the hour.

Table 1: Relative merits and demerits of Jute sacks and HDPE/PP woven sacks

Sl. No.	Jute bags	HDPE/PP woven sacks
1	Good stack stability	Poor stacking and destacking (unstable stacks with perpetual chances of stack collapse). This has been solved to some extent by woven sacks with rough surface.
2	Higher incidence of bag damage indicating poor end use performance	Better endurance and recyclable
3.	Amenable for use of hooks and better reclosure	Poor recovery of holes caused by hooks which increases grain seepage.
4.	Poor mechanical strength	Good mechanical strength and lends for re-use
5.	Natural and have no problem with standards	Synthetic needs to be checked for safety.
6.	Contamination of food grains by jute batching oils present in the jute bags may occur	No such contaminations can occur

Table 2: Insect Resistance of some films and laminates

Films	Time of penetration in months for different insects			
	Sitophilus oryzee	**Rhizopertha dominica**	**Stegobium panicium**	**Tribolium castaneum**
LDPE 200 G (guage)	3	3	> 3	3
LDPE 400 G	2	2	> 3	> 3
HDPE 100 G	¼	2	> 3	> 3
HDPE 200 G	2	2	> 3	> 3
HDPE 300 G	> 3	> 3	> 3	> 3
Polypropylene 200 g	> 3	> 3	> 3	> 3
Polypropylene 300 g	> 3	> 3	> 3	> 3
300 MXXT Cellophane	¼	1	> 3	> 3
300 MXXDT Cello LDPE 150 g	1	2	-	-
PET 50 G/LDPE 300G	> 3	> 3	> 3	> 3
MET.PET 50 G/LDPE 150 G	> 3	> 3	> 3	> 3
PET 50 G/Al. Foil 0.02 mm/LDPE 150 G	> 3	> 3	> 3	> 3
300 Cello / Al. Foil 0.02 mm/LDPE 150 G	> 3	> 3	> 3	> 3

Table 3: Permeability of Fumigants Though Films and Laminates

Sl No	Films	Methyl bromide 32 mg/L			Ethylene dibromide 32 mg/L			Methyl formate 32 mg/L			Ethyl Formate 44 mg/L			Phosphine 1.5 mg/L		
		MC	P%	PR	MC	P%	PR	MC	P%	PR	MC	P%	PR	MC	P%	PR
1	HDPE 100G (gauge)	14.7	31.0	42.0	11.2	35.0	63.0	20.7	47.0	113.0	12.4	40.5	72.9	0.24	16.0	1.3
2	HDPE 200G	14.5	30.0	41.0	9.3	28.5	51.0	6.5	20.5	50.1	5.8	24.0	43.2	0.0	0.0	0.0
3	HDPE 300G	12.9	23.3	29.0	6.1	18.8	34.0	6.0	15.0	36.4	7.0	21.2	36.4	0.0	0.0	0.0
4	Polyethylene 200 G	14.5	30.0	41.0	9.2	28.5	31.0	7.4	17.0	41.0	8.7	29.1	52.4	0.05	3.2	0.26
5	Polyethylene 300 G	11.6	18.0	25.0	9.2	28.5	31.0	3.0	7.2	71.3	7.0	24.0	43.2	0.0	0.0	0.0
6	300 MXXT Cello	12.7	22.3	31.0	9.0	27.9	49.0	20.7	47.1	113.9	2.9	26.5	47.8	0.25	16.6	1.3
7	300 MXXT Cello LDPE 150G	8.7	6.4	9.0	8.0	28.9	46.0	25.7	25.4	61.5	13.9	44.3	79.6	0.14	8.8	0.72
8	PET 50 G/LDPE 300 G	11.4	17.5	24.0	4.2	30.0	23.0	18.6	42.4	102.5	14.5	46.8	84.3	0.5	3.2	0.26
9	Met. PET 500/LDPE150G	12.2	20.8	28.0	0.0	0.0	0.0	13.2	30.1	72.9	7.9	26.5	47.8	0.0	0.0	0.0
10	PET 50 G/Al. Foil 0.02	10.4	13.2	18.0	7.3	20.7	40.0	17.8	40.5	78.0	8.3	27.8	50.1	0.0	0.0	0.0

	mm/ LDPE 150 G															
11	Paper 60 G/Al. Foil 0.02 mm/ LDPE 150 G	12.4	26.1	29.0	5.9	18.8	32.0	5.7	13.2	31.9	5.4	19.0	34.1	0.0	0.0	0.0
12	Paper 60 G/Al. Foil 80 G/0.02 mm/ LDPE 150 G	5.0	15.3	27.0	5.5	16.2	28.0	2.0	4.7	11.3	2.5	10.1	18.2	0.0	0.0	0.0
13	Glassine 40 gsm	8.7	6.6	9.0	6.4	20.0	23.0	22.0	50.0	120.7	8.3	27.8	50.1	0.05	3.2	0.26

Plastics in Food Packaging

Introduction The global market is flourishing day by day with different innovative and designed polymeric packaging materials. Today, plastic has almost replaced metal, wood, glass and paper in the field of packaging and there appears no substitute for the plastics. Plastic is considered as one of the greatest inventions of the millennium. It has become the most vital material at present and also for the future of our nation. Especially there has been enormous development in the field of food packaging with plastics. Food requires protection from various environmental factors from the time of its production till it is consumed. Hence, packaging is required to protect the food. The shelf life of packaged foods may range from a few days to more than a year. Thus, the properties of packaging material must have sufficient permanence to assure that shelf life is not compromised. This is not to say that the package is entirely responsible for shelf life retention. Foods deteriorate with time even with complete protection. Moreover, packages, with rare exceptions cannot improve on the original quality of the food itself.

Advantages of Plastics

Many properties of plastics make them ideally suited for food packaging. In most cases, it is a combination of properties that enables plastics to win the battle for adoption in comparison to other traditional packaging materials used in food packaging. Plastics ability to provide lightweight packages, which is an important consumer convenience factor and a way for processors to reduce shipping cost, is probably the largest single driving force behind plastics penetration of the market for food containers that were once the exclusive province of metal and glass. Densities of 0.9 to 1.4 g/cc are typical for most plastics used in packaging. This density range compares to about 2.6 for glass, 2.7 for aluminum, 0.8-0.9 for paper, 1.5 for polymer coated cellophane, and about 8 for steel. Plastics are able to create strong hermetic seals at low temperatures (100-250°C). Incorporating an oxygen barrier in all-plastic flexible package can be accomplished by including a barrier plastic layer in a multilayer construction. Recent developments in extruded barrier polymers and co-extrusion technology have allowed plastics to penetrate the rigid packaging market for some oxygen-sensitive food applications. Plastic films remain flexible at low temperatures use. Very thin coatings of aluminum can be readily vapour deposited on plastic substrates in high vacuum chambers. The resulting attractive product in less

expensive than sometimes functionally superior to aluminum foil, which is sued in flexible packages to provide a barrier to light, moisture, and oxygen.

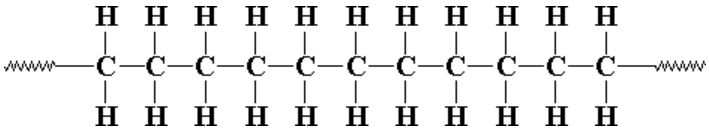
Thermoplastics make up the greatest share of plastic usage in food packaging because they can be rapidly formed economically into any shape needed to fulfill the package function, and are especially amenable to recycling and waste-to-energy conversion. The principal families of thermoplastics in food packaging are the polyolefins (low density or high density polyethylene, polypropylene etc.), polystyrene, polyester, nylon, polycarbonate and vinyl polymers.

Polyolefins

The polyolefins form an important class of thermoplastics and include Polyethylene, polypropylene and some other olefinic copolymers which are among the most widely used food packaging plastics, in the form of films, mouldings, coatings, adhesives and closures. A great variety of types and grades polyolefins are growing steadily as manufacturers find new compositions to satisfy specific needs (photo 1).

Polyethylene

Polyethylene is probably the polymer we see most in daily life. It is the most popular plastic in the world. This is the polymer that makes grocery bags, shampoo bottles, children's toys, and even bullet proof vests. For such a versatile material, it has a very simple structure, the simplest of all commercial polymers. A molecule of polyethylene is nothing more than a long chain of carbon atoms, with two hydrogen atoms attached to each carbon atom.



Structure of polyethylene

Sometime some of the carbons, instead of having hydrogens attached to them, will have long chains of polyethylene attached to them. This is called branched, or low-density polyethylene, or LDPE. When there is no branching, it is called linear polyethylene, or High Density Polyethylene (HDPE) (Fig.1). Linear polyethylene is much stronger than branched one.

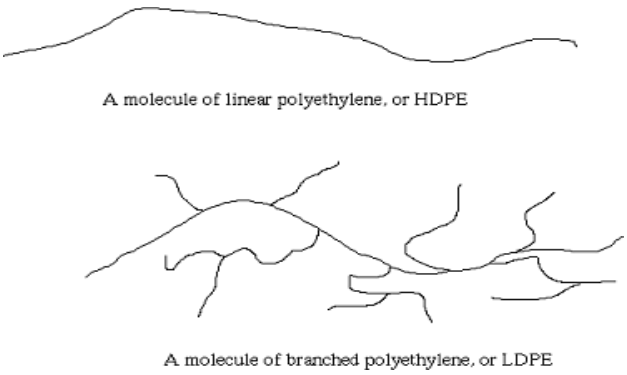


Fig. 1. Outline of linear and branched polyethylene

It is normally produced with molecular weights in the range of 200,000 to 500,000, but it can be made even higher. Polyethylene with molecular weights of three to six million is referred to as ultra-high molecular weight polyethylene, or UHMWPE. UHMWPE can be used to make strong fibers used in bullet proof vests.

Low Density Polyethylene (LDPE)

This is the largest volume single polymer used in food packaging in both the film and blow-molded form. The polymerization of ethylene can occur over a wide range of temperatures and pressures but most commercial high pressure process utilize pressures between 1000 and 3000 atmosphere and temperatures between 100° and 350° C, higher temperatures causing degradation of the polyethylene.

The crystallinity of LDPE usually varies between 50 and 70%. The softening point is affected by chain branching. Because the chains are unable to approach each other closely, the attractive forces between them are reduced and less energy (in form of heat) is necessary to cause them to move relatively to each other and thus flow. The softening point of LDPE is just below 100°C, thus precluding the use of steam to sterilize it in certain food packaging.

LDPE is a tough, slightly translucent material, which can be blown extruded into tubular film, or extruded through a slit die and chill-roll cast, the latter process giving a clearer film. It has good tensile strength, burst strength, impact resistance and tear strength, retaining its strength down to –60°C. While it is an excellent barrier to water and water vapour, it is not a good barrier to gasses.

It has excellent chemical resistance, particularly to acids, alkalis and inorganic solutions, but is sensitive to hydrocarbons and halogenated hydrocarbons and to oils
and greases. These compounds are absorbed by the LDPE, which then swells. Environmental stress cracking (ESC) is a phenomenon, which occurs when a material is stressed multi-axially while in contact with certain polar liquids or vapours, resulting in surface cracks or even complete failure of the material. Essential and vegetable oils are capable of causing ESC but the effect can be greatly reduced by using high molecular weight grades of LDPE. One of the great attributes of LDPE is its ability to be fusion welded to itself to give good, tough, liquid-tight seals.

LDPE is also used as a rigid packaging material. It can be easily blow moulded into bottles where its flexibility enables the contents to be squeezed out. It is also widely used in the form of snap-on caps, collapsible tubes and a variety of spouts and other dispensers. The surface of polyethylene containers can be treated with fluorine after blow molding to form a very thin polar, cross-linked surface, which decreases the permeability of the polyethylene to non polar penetrants. It also eliminates the need for treating the surface by corona-arc discharge or flame techniques to improve printability properties. Polyethylene is one of the most inert polymers and constitutes no hazard in normal handling.

Linear Low Density Polyethylene (LLDPE)

A major feature of LLDPE is that its molecular weight distribution is narrower than that of LDPE. Generally, the advantages of LLDPE over LDPE are improved chemical resistance, improved performance at both low and high temperatures, higher surface gloss, higher strength at a given density and a greater resistance to environmental stress cracking. In film form, LLDPE shows improved puncture resistance and tear strength. At a density of 0.92 g/cm^3 the melting points of LDPE and LLDPE are 95°C and 118°C respectively. LLDPE commonly has a density of around 0.92 g/cm^3 with butene in particular as the comonomer. The superior properties of LLDPE have led to its use in new applications for polyethylene as well as the replacement of LDPE and HDPE in some areas, specially in liquid packaging of milk, oil and arrack etc.,

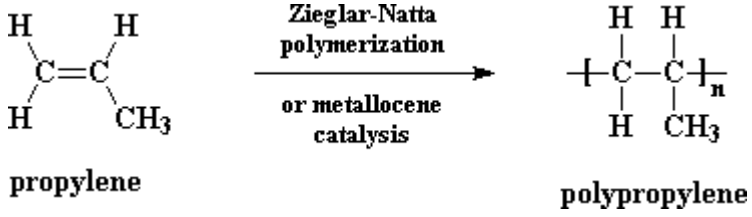
High Density Polyethylene (HDPE)

HDPE is prepared by polymerizing ethylene at a low pressure and ambient temperatures. Use of pressures at 27-34 atmosphere and temperatures of 100°C –175°C. Relatively low pressure/low temperature polymerization process produce HDPE. HDPE possesses a much more linear structure than LDPE and has up to 90% crystallinity, compared with LDPE which exhibits

as low as 50%. Although some branch chains are formed, these are short and little in number. HDPE film is stiffer and harder than LDPE and densities range form 0.94-0.96 g/cm^3. Its softening point is about 121°C, and its low temperature resistance is about the same as LDPE. Tensile and bursting strengths are higher but impact and tear strengths are both lower than LDPE due to the linear nature of the HDPE molecules. They tend to align themselves in the direction of flow and thus the tear strength of the film is much lower in the machine direction compared to the transverse direction. The chemical resistance of HDPE is also superior to that of LDPE and, in particular, it has better resistance to oils and greases. The film offers excellent moisture protection, a much decreased gas permeability compared with LDPE film, but is much more opaque. Heat sealing is considerably more difficult compared to LDPE film. HDPE film has a white, translucent appearance and therefore tends to compete with paper. HDPE is blow molded into bottles, Jars, jerricans etc., for a variety of food packaging application.

Polypropylene (PP)

Structurally, PP is a vinyl polymer, and is similar to polyethylene, only the backbone chain has a methyl group attached to it on every other carbon atom.



Structure of Polypropylene

PP can be blown moulded and injection molded, the latter process being widely used to produce closures and thin walled pots and crates. The glass transition temperature of PP is placed between 10°C and –20°C with the result that the polymer becomes brittle as subzero temperatures are approached. Copolymerization with 4-15% of ethylene improves the strength and lowers the Melting temperature(T_m) and Glass transition (T_g) slightly; such copolymers are often preferred to the homopolymer in injection molding and bottle blowing applications, and also find use in shrink-wrapping where the lower melting point is an advantage.

PP has a lower density (0.90 g/cm^3) and a higher softening point (140° - 150°C) than the polyethylenes, low water vapor transmission, medium gas permeability, good resistance to

greases and chemicals, good abrasion resistance, and high temperature stability, as well as good gloss and high clarity, the latter two factors making it ideal for reverse printing.

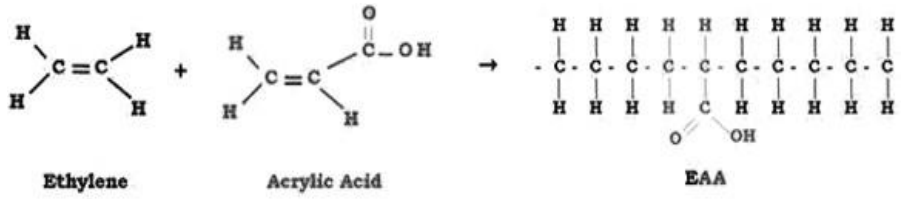
Non-oriented PP film is often referred to as cast PP (CPP) film because it is generally made by the chill-roll cast process, although other methods can be used. PP film is a very versatile material; being used as a thermoformable sheet, in cast form for film and bags, and as thin, strong biaxially oriented films for many applications. Cast and oriented PP are sufficiently different that they do not compete for the same end use. The cast form has polyethylene type uses while the oriented form has regenerated cellulose-type uses. The cost of cast PP is much lower than that of oriented PP. Cast PP use in food packaging is limited owing to its brittleness at below-freezing temperatures, and it is generally not recommended for use with heavy, sharp or dense products unless laminated to stronger, more puncture-resistance materials. The relatively high temperature resistance of PP permits its use as the seal layer in retortable pouches where temperatures of up to 130°C are encountered.

In recent years there has been a large increase in the use of both side oriented polypropylene (BOPP) for food packaging. Biaxially oriented (BOPP) film has a high clarity since layering of the crystalline structures reduces the variations in refractive index across the thickness of the film and this in turn reduces the amount of light scattering. The blown tubular or high expansion bubble process, or the tenter frame process can produce OPP. BOPP film has a tensile strength in each direction roughly equal to four times that of cast PP film. Although tear initiation is difficult, tear resistance after initiation is low. Biaxial orientation also improves the moisture barrier properties of PP film and its low temperature impact strength. OPP film is not considered to be a gas barrier film but this deficiency can be overcome by coating with poly vinylidene chloride (PVdC) copolymer, which also helps in heat sealing. The PVdC copolymer confers far better resistance to water vapor and oxygen permeability.

Ionomers

Ionomers are prepared by co polymerizing ethylene with a small amount of 1 – 10% unsaturated carboxylic acid such as methacrylic acid/acrylic acid using the high pressure process. These polymers are called ethylene acrylic acid copolymer (EAA)/ethylene methacrylic acid copolymer (EMA). Further such copolymers are then neutralized to varying degrees with the derivative of a metal such as sodium methoxide or magnesium; ionize cross links which confer

enhanced stiffness and toughness (the puncture resistance of ionomer film is double than that of LDPE film of the same gauge) on the material at ambient temperatures. One example of an ionomer is poly(ethylene-*co*-methacrylic acid). This polymer is a sodium magnesium, or zinc salt (which provides the ions) of copolymers derived from ethylene and methacrylic acid. In an ionomer, the nonpolar chains are grouped together and the polar ionic groups are attracted to each other. This allows thermoplastic ionomers to act in ways similar to that of crosslinked polymers or block copolymers. In comparison with LDPE, ionomer/EAA/EMA films have excellent oil and grease resistance, excellent resistance to stress cracking, greater clarity, lower haze, greater abrasion resistance and a higher moisture vapor permeability due to lower crystallinity.

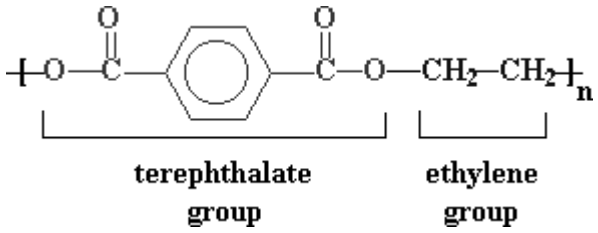


Structure of Ethylene Acrylic Acid copolymer

Photo 1. Polyolefin based Food Packaging material (LDPE/LLDPE/HDPE/HMHDPE/PP)

Polyesters

Simple polyesters are derived form condensation of polyhydric alcohol and a polyfunctiorial acid . Each components needs a functionality (i.e., number of reactive groups such as -OH, -COOH, per molecule of 2 to form a linear chain, while if one (or both) monomers have a functionality of at least 3, cross-linkage can occur resulting in a much more rigid 3-D lattice structure. Polyethylene terephthalate (PET) can be produced by reacting ethylene glycol with terephthalic acid, although in practice the dimethyl ester of terephthalic acid is used to give a more controllable reaction.



Structure of Polyethylene terephthalate

PET has a melting point (T_m) of 267°C and a glass transition point (T_g) between 67° to 80°C. PET films are most widely used in the biaxially oriented, heat stabilized form. There are virtually no applications for the material in its un-oriented form because, if crystalline, it is extremely brittle and opaque, and if amorphous, it is clear but not tough. In a two-stage process, machine direction stretching induces 10-14% crystallinity and this is raised to 20-25% by transverse orientation. In order to stabilize the biaxially orientation the film is annealed (or heat set) under restraint at 180°-210°C, which increases the crystallinity to around 40% without appreciably affecting the orientation, and reduces the tendency to shrink on heating. Subsequent coatings are applied to obtain special barrier properties, slip characteristics or heat sealability.

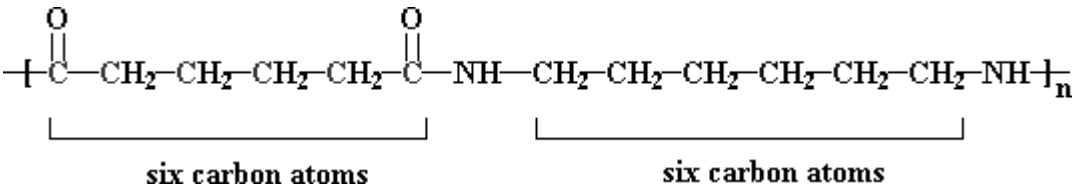
PET film's outstanding properties as a food packaging material are its great tensile strength, excellent chemical resistance, lightweight, elasticity and stability over a wide range of temperatures (-60° to 220°C). This latter property has led to the use of PET for "boil-in-bag" products, which are frozen before use (the PET is usually laminated to or extrusion coated with LDPE and is typically the outside and primary support film of such laminations), and as oven bags where they are able to withstand cooking temperatures without decomposing (photo 2).

Photo 2. Polyester based Packaging materials

Metallization of PET films results in a considerable improvement in barrier properties. A reduction in water vapor transmission rates by factor of 40 and oxygen permeabilities by over 300 is obtained. Metallization PET laminated with LDPE films is used in most of the snacks and bakery items.

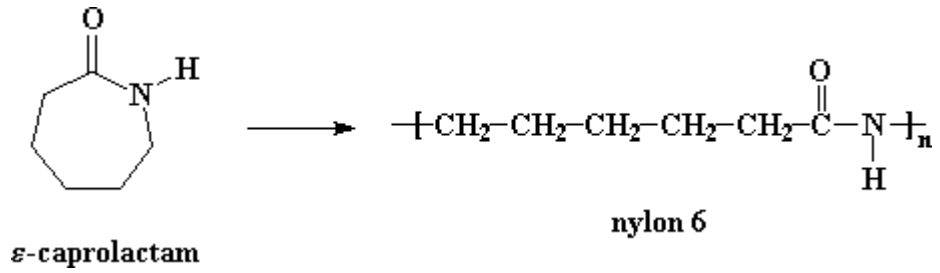
Polyamides (Nylons)

Nylons are one of the most common polymers used as a fiber. Nylon is found in clothing all the time, but also in other places, in the form of a thermoplastic films. Nylons are also called polyamides, because of the characteristic amide groups in the backbone chain. These amide groups are very polar, and can hydrogen bond with each other. Because of this, and also due to its regular and symmetrical backbone, nylons are often crystalline, and make very good fibers. Nylon in this picture is called nylon 6,6, because each repeat unit of the polymer chain has two stretches of carbon atoms, each being six carbon atoms long. Other nylons can have different numbers of carbon atoms in these stretches. It is usually made by reacting adipic acid with hexamethylene diamine:



Structure of polyamides Nylon 6, 6

Another kind of nylon is nylon 6. It's a lot like nylon 6,6 except that it only has one kind of carbon chain, which is six atoms long.



Structure of polyamide (Nylon 6)

It is made by a ring opening polymerization from the monomer caprolactam. Nylon 6 doesn't behave much differently from nylon 6,6. Several nylons have been produced with greater than six-carbon chains, as they result in films with a lower melting point and an increased resistance to water vapour. Again, the key to successful commercialization is to find cheap sources of the monomers. In general nylons are highly permeable to water vapour, the absorbed water having a plasticizing effect which causes a reduction in tensile strength and an increase in impact strength. Their permeability to oxygen and other gases is quite low when the films are dry. PVdC copolymer coated nylons offer improved oxygen and moisture vapour and UV light barrier properties. Odor retention is excellent and the films are tasteless, odourless and nontoxic. Mostly it is used as a middle layer in coextruded films used in oil packaging with a contact layer of EAA and LDPE as outer layer.

Polystyrene – (PS)

If ethylene and benzene are reacted together with a suitable catalyst, ethyl benzene is formed. Further a process of dehydrogenation produces styrene. Polystyrene (PS) is made by the addition polymerization of styrene. Polystyrene is a vinyl polymer. Structurally, it is a long hydrocarbon chain, with a phenyl group attached to every other carbon atom. Polystyrene is produced by free radical vinyl polymerization, from the monomer styrene.

Structure of polystyrene

Photo 3. Polystyrene based Food Packaging material (Disposable/Thermo formed/Trays and Containers)

Polystyrene is an inexpensive and hard plastic, and it also is made in the form of foam packaging and insulation (Styrofoam is one brand of polystyrene foam). Clear plastic disposable drinking cups used for serving tea and ice creams are made of polystyrene (photo 3).

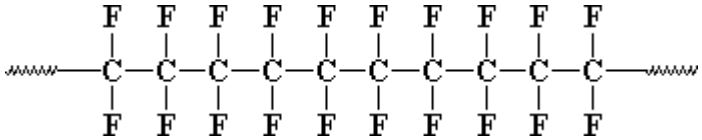
Polystyrene makes a distinctly metallic sound when dropped onto a hard surface. It has a high refractive index (1.592), which gives it a particular high brilliance. Although acids and alkalis have no effect on it, it is soluble in higher alcohols, ketones, esters, aromatic and

chlorinated hydrocarbons and some oils. While a reasonably good barrier to gasses, it is a poor barrier to water vapor. To overcome the brittleness of polystyrene, synthetic rubbers can be incorporated at levels generally not exceeding 14% w/w. The rubbers act by restricting propagation of microcracks formed during impact loading. Such a process increases the impact strength and flexibility, the transparency, tensile strength and thermal resistance is much reduced. The chemical properties of this toughened, or high impact, polystyrene (HIPS) are much the same as those for unmodified polystyrene.

HIPS is an excellent material for thermoforming. Because it is transparent, the use of radiant heat for thermoforming is inefficient and pigmented sheet is often used. It is injection molded into tubs, which find wide use in food packaging, despite their being opaque. Crystal grade PS can be made into a film but it is brittle unless the film is biaxially oriented.

Poly (tertrafluoroethylen) - (PTFE)

The high thermal stability of the carbon-fluorine bond has led to considerable interest in fluorine-containing polymers are set apart from other vinyl polymers because their monomers are the only ones which need not bear any hydrogen on the ethylenic carbons in order to be polymerizable. PTFE was a chance discovery by Plunkett in 1938. today it accounts for about 80% of the fluorinated polymer produced and is commonly referred to as Teflon. Polytetrafluoroethylene, or PTFE, is made of a carbon backbone chain, and each carbon has two fluorine atoms attached to it.



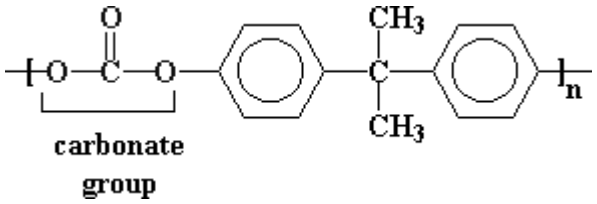
Structure of Teflon

Fluorine is a very strange element. When it is part of a molecule, it doesn't like to be around other molecules, even the fluorine atoms on other molecules. But it likes other kinds of molecules even less. So a molecule of PTFE, being just chock full of fluorine atoms as it is, would like to be as far away from other molecules as it can get. For this reason, the molecules at the surface of a piece of PTFE will repel the molecules of just about anything that tries to come

close to it. This is why nothing sticks to PTFE. In food packaging, PTFE finds wide use as a non-stick separating surface between thermoplastic films and the jaws of heat sealers. It is common to use a band of PTFE (often reinforced with glass fibers) on continuous heat sealers. Polytetrafluoroethylene is better known by the trade name Teflon. It is used to make non-stick cooking pans, and anything else that needs to be slippery or non-stick. Then there is the fact that the bond between the fluorine atom and the carbon atom is just really, really strong. The bond is almost bullet proof! It's so stable that nothing will react with it. Even when it gets as hot as a frying pan, not even oxygen will react with it.

Polycarbonates

Polycarbonates (PC) are polyesters of unstable carbonic acid and have carbonate (-O, CO O-) linkages. Polycarbonate, or specifically polycarbonate of bisphenol A, is a clear plastic used to make shatterproof windows, lightweight eyeglass lenses etc,.



Structure of polycarbonte

Polycarbonate gets its name from the carbonate groups in its backbone chain. It is called as polycarbonate of bisphenol A because it is made from bisphenol A and phosgene. Polycarbonate is outstanding in its combination of high temperature resistance, high impact strength and clarity, retaining its properties well with increasing temperature. Chemically it is resistant to dilute acids but is strongly attacked by alkalis and bases such as amines. Its permeability to both water vapor and gases is high, and if appreciable barrier properties are required, it must be coated. While it can be oriented, there is no decrease in permeability although its tensile strength increases. It is not suitable as a shrink film since its rate of shrinkage above its heat distortion point is extremely slow.

Photo 4. Polycarbonate baby feeding bottles

Due to its high softening point PC is also used in making feeding bottles for infants (photo 4). These bottles scan be heat sterilized at high temperature. The film has been used for boil-in-bag packs and, when coated with LDPE, skin packaging. Because of its good stability at high temperatures, uses as a retort pouch and for microwave oven cookware are envisaged.

A common application for PC is baby feeding bottles for high temperature sterilization.

Ethylene-vinyl Acetate - (EVA) and Ethylene-vinyl Alcohol (EVOH)

EVA with a vinyl acetate (VA) content of 3-12% are similar in flexibility to pla and EVOH copolymers sticized PVC, and have a good low temperature flexibility and toughness. Their impact strength increases with VA content and molecular weight. As the VA level increases, EVA becomes less crystalline and more elastic; as the crystallinity decrease, the permeability to gases, moisture, fats and oils increase. The absence of leachable plasticizer provides a clear advantage over plasticizer PVC in some food applications. The addition of antiblocking and /or slip additives reduces sparkle and clarity, and increase haze.

The most outstanding characteristic of EVOH resins is their ability to provide a barrier to gasses. Their use in a packaging structure enhances flavour and quality retention by preventing oxygen from penetrating the package. In those applications where gas-fill packaging techniques are used, EVOH resins effectively retain the carbon dioxide or nitrogen used to blanket the product.

Laminates/co-extruded films

As can be seen from Table 1 no single polymer possesses all the desirable properties that may be required and, as the range of possible applications in the food industry is so diverse, there

can be no such thing as the ideal universal packaging material. Optimum properties in each individual case can frequently only be achieved by recourse to several polymers and even non-plastic materials such as aluminium or paper, in combination. Such combinations, or laminates, consist of layers of individual materials on top of each other and bonded together by adhesives. Some of the individual resins can also be co-extruded to get the required barrier properties for better shelf life of the food products. Some of the laminates/co-extruded films available today in the market for food packaging applications are shown in the Table 2 with their barrier properties.

Laminate - Tetra Aseptic brick packaging material for juices & UHT milk

Tetra Pak Aseptic cartons are multi-layer (usually six layer system) polycoated paperboards, made up of mainly paperboard (approximately 75% of the total package weight) The barrier layers consist of four or five layers of low-density polyethylene and one very thin layer of aluminum, which accounts for 5% of the total weight.

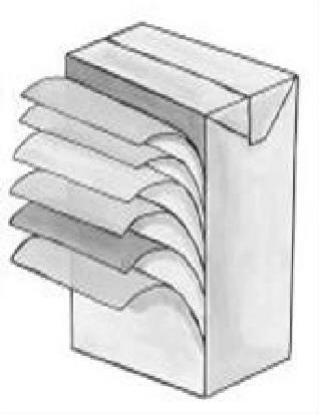


Fig 2. Multilayer laminates of Tetra pack Aseptic packaging

Innermost contact heat sealable layer of polyethylene in contact with liquid is needed for lamination process. Aluminium foil provides a barrier to oxygen, flavours and light. Polyethylene adhesion layer is needed for lamination process. Paperboard gives stability and strength. Outer polyethylene layer protects food from external moisture.

Co-extruded Barrier films for edible oils

Typical 5 layer co-extruded film consists of LDPE or LLDPE/Tie/Nylon 6/Tie/EAA is used for oil packaging. Mostly, it is a combination of these materials which results in a strong barrier film that proves to be a perfect barrier against oxygen and moisture, as well as microbes. Ethylene Acrylic Acid Copolymer is important layer as a sealant layer, and it proves an excellent seal

integrity through oil contamination with good hot tack. Middle layer Nylon is covered with LDPE or LLDPE for protection from moisture. Nylon acts as a barrier layer for oxygen, and flavor for better shelf life of oils (photo 5).

Photo 5. Coextruded LDPE/LLDPE/Tie/Nylon/Tie/EAA pouch for oil packaging.

Table 1: Properties of major packaging resin film (data based on ONE MIL thickness)

	LDPE	**LLDPE**	**HDPE**	**PP**	**OPP***	**PVC**	**PVDC**
Density (g/cc)	0.91-0.925	0.918-0.923	0.945-0.967	0.91	0.90	1.22-1.36	1.6-1.7
Yield (m^2/kg; 1 mil)	42.6	42.5	41.2	44	44	28	24
Tensile Strength (kpsi)	1.5-5	3-8	2.5-6	30-40	20-30	4-8	8-16
Tensile modulus 1% Secant (kpsi)	20.40	25	125	300	350	350-600	50-150
Elongation at break (%)	200-600	400-800	200-600	200-350	50-275	100-400	50-100
Tear strength (graves) (lb/in)	100-500	-	-	-	1000-1500	100-300	2
Tear strength (elmendorl) (gm/mil)	100-200	150-900	200-300	-	340	400-700	10-90
WVTR g/m2/day at 38°Cand 90% RH	14-18	14-18	5-7	7-9	4	30-40	2-4

O_2 Permeability (cc/m^2 /day atm25°C	7000-8000	7000-8000	1500-2000	2000-3000	2000-2500	300-400	5-25
Haze (%)	5-10	6-13	3	3	3	1-2	1-5
Light transmission (%)	65	-	-	80	80	90	90
Heat Seal temperature range (°F)	250-350	220-340	275-310	200-300	200-300	280-340	250-300
Service temperature (°F)	-70 to 180	-20 to 220	-40 to 250	40 to 250	40 to 250	-20 to 150	0 to 275

	IONOMER	**PET**	**PC**	**BON**	**OPS**	**EVA**	**EVOH**
Density (g/cc)	0.94-0.96	1.4	1.2	1.14	1.05	0.93	1.14-1.19
Yield (m^2/kg; 1 mil)	42.0	28.4	32.5	35	38	41.9	32.7-34.7
Tensile Strength (kpsi)	3.5-5	25-33	9-11	25.37	8-12	2-3	1.2-1.7
Tensile modulus 1% Secant (kpsi)	10-50	700	320	250-300	400-475	8-20	300-385
Elongation at break (%)	300-600	70-130	100-150	70-120	2-30	500-800	120-280
Tear strength (graves) (lb/in)	-	1000-2000	800-1600	500-800	300-1000	100-500	-
Tear strength (elmendorl) (gm/mil)	20-40	20-100	20-50	15-30	2-15	40-200	400-600
WVTR g/m2/day at 38°Cand 90% RH	20-30	21	50-100	150	100-150	20-50	20-50
O_2 Permeability (cc/m^2 /day atm25°C	7000-8000	50-80	3000	25-40	4000-5000	10000	0-5.2
Haze (%)	1-15	2	1	1.5	1	2-10	1-2
Light transmission (%)	85	88	89	88	92	55-75	90
Heat Seal temperature	225-300	275-	400-	250-	250-350	150-	350-400

range (°F)		350**	420	350**		350	
Service temperature (°F)	-150 to 150	-100 to 300	-210 to 280	-100 to 400	-80 to 175	-100 to 150	0 to 300

Table 2 : Barrier properties of multilayer flexible packaging materials

Packaging materials	**Thickness (µm)**	**WVTR**	**OTR**
Laminates:			
PET/LDPE	12/37	9.5	75
PA/IONOMER	25/50	7.2	85
MET.PET/LDPE	12/37	1.5	4
PET/HDPE-LDPE	12/112	3.3	75
MET.PET/HDPE-LDPE	12/112	0.6	2
PET/ LDPE/ IONOMER	12/25/25	6.4	70
HDPE/ IONOMER	25/25	3.8	1395
PAPER/FOIL/ LDPE	40/9/37	-	-
PET/FOIL/LDPE	12/9/10	-	-
PET/PP		-	-
PET/FOIL/PP		-	-
Co-Extruded Films:			
LDPE/LLDPE			
LDPE/ HDPE	120	2.0	670
HDPE/ LDPE/HDPE	110	-	-
HDPE/ LDPE/EAA	110	2.1	766
LDPE/BA/PA/BA/EAA	90	5.4	46
CPP/BA/PA/BA/EAA	90	4.1	45

Machinery for primary packaging operations

Introduction:
The basic operations involved in primary packaging operations are pouch forming, product filling, weighing/counting and pouch sealing. A great variety of packaging equipment's are available, ranging from simple manually operated units to complicated, high speed, integrated machines with sophisticated controls. Standard machines of various basic types are available for most purposes but, some times, special machines must be designed for high speed or for products or for packages with unique characteristics. These machines are designed suitable for products which vary in its physical form and characteristics. The products are categorized in terms of its physical form like solid, liquid, gas and further as powder, paste, granular etc., high viscous & low viscous products, corrosive & non corrosive products etc. The principle of operation of the machine and the material of construction depends on the above said product characteristics. This paper discusses about different filling equipment's and their principles of operation.

Filling equipment classification:
Filling equipment types have been designed for a great variety of solid, liquid and gaseous products with various characteristics.

Liquid product systems:
The liquid system uses two main design principles as shown in figure 1.

- Fill height level
- Constant volume control

Figure 1.

Fill height level:
In this method the liquid is filled to a predetermined level in the container irrespective of variations in the volume of the container.

Four filling methods are used under this principle

- Vacuum
- Gravity
- Pressure
- Pressure-Vacuum

In addition to the above major filling methods, some other methods like, pneumatic, sonic or electronic level controls are also occasionally used.

Constant Volume control:
Two basic methods are used under this principle.

- Piston

- Metering

The measured volume of product is controlled by factors such as costs, end use or net weight. The great advantage with liquid filling is that they have consistent density and therefore, controlled volume filling results in consistent weight control.

Dry product systems:
Dry product system uses the following four methods.

- Auger filling or volumetric flask
- Vacuum
- Net weight
- Countering

Gaseous product systems:
Gaseous product system uses two basic methods

- Cold filling liquefied gases
- Pressure filled compressed gases

LIQUID FILLERS

Vacuum Filling

Vacuum filling is used normally when filling free flowing liquids into glass containers. Its popularity is due to good flexibility and low cost. The principle of operation of vacuum filling is shown in figure 2.

Machine of this type employ a filling stem which consists of a tube through which the product flows into the container and a tube connected to the vacuum system. There are dozens of styles of filling tubes with the final design dictated by the product, container, and filling conditions.

When the filling stem is inserted into the container, the top of the bottle contacts the seal ring and immediately air is drawn from the container through the vacuum system. This decreases the pressure in the container compared with the atmospheric pressure on the product in the supply tank, thus forcing the liquid from the supply tank, through the filling tube and into the container. The fill cycle continues until the product level covers the vacuum tube inlet. The product at this level is drawn through the vacuum system. The level at which the liquid is drawn out of the container by the vacuum system has been preset and is known as the “fill height level”.

The product drawn off through the vacuum system is separated from the air being drawn from other containers (which may not have yet reached their “fill height level”) into a separator jar where the product, being heavier than the air, falls to the bottom and is either returned to the supply tank if no foam were produced or, alternatively, pumped into a settling tank.

Vacuum filling to a “fill height level” is generally preferred for glass due to the inaccuracies of the volume measurement of glass. For this reason, all glass containers, when filled to a predetermined fill height level, will contain slightly different volumes of product.

Vacuum fillers for liquid products are available from a simple single tube unit to continuous motion rotary fillers incorporating as many as 60 or 70 filling stems, which would offer production speeds of 500 to 600 bottles per minute.

Vacuum filling is chosen when:
- “Filling height level” measure of fill is desired
- The container will withstand the vacuum
- The product is free flowing
- Agitation of product does not matter

Figure 2.

Gravity Filling

Gravity filling employs the force of gravity to achieve container fill. A supply tank is elevated above the filling tube. The filling tube is similar to the vacuum tube except that no vacuum is applied. The product falls into the container when the filling tube value is opened. Normally, a sliding outer tube is used with the neck of the bottle raising the outer tube and opening a valve. Since there is no vacuum draw off, the outer tube is spring loaded to eliminate drip before and after filling. The principle of operation of gravity filling is shown in figure 3.

The product flow into the container by gravity continues until the "fill height level" is reached, after which the product entering the container is forced up through the overflow tube into an overflow tank where it can be held or returned to the product supply tank.

Gravity filling may be employed for filling products which have foaming characteristics. The flow rate of the product into the container is slower and product velocity is minimal. This reduces the agitation which is the cause of foam. If the product is exceptionally foamy, however, gravity filling should not be employed. Bottom filling would be best.

Gravity filling is used when:
- "Fill height level" is desired
- Container will not withstand vacuum
- Product is free flowing
- Agitation is not desirable

Figure 3.

Pressure Filling

Pressure filling is used where the liquid is not free flowing and where product agitation is not desirable. This system is similar to the gravity system except that a pump is used to increase the flow rate over that obtained by gravity. The principle of operation of pressure filling is shown in

figure 4. A supply tank need not be elevated with a pressure filling system and may be eliminated by drawing directly from a main supply tank. In all other respects, the system is the same as gravity filling.

Pressure filling is used when:
- "Fill height level" is desired
- Product is not free flowing
- Container will not withstand vacuum
- Agitation is not desirable

Figure 4.

Pressure-Vacuum

This combines the vacuum system with the pressure system. It is used when the product flow rate is too slow on a straight vacuum system, due to the inability of the container to withstand high vacuum. The principle of operation of pressure-vacuum filling is shown in figure 5.

This pressure vacuum system is properly used when filling rigid polyethylene containers. On this type of container, only a low vacuum can be maintained before the side walls of the container collapse, and at this low vacuum, the product flow rate is too slow. The pump is incorporated to increase the product flow rate. Excess product is pushed up the vacuum tube once the "fill height level" is achieved.

This is a dangerous method of filling very viscous products since, when the container reaches its "fill height level", considerable pressure is required to force the excess viscous liquid out of the smaller overflow tube: Air may be forced out of the top of the container through the seal at the neck rather than the product being forced up the overflow tube.

Pressure vacuum filling is used when:
- "Fill height level" is desired
- Product is non-free flowing
- Container will not withstand high vacuum
- Agitation is not a problem

Agitation creates foam in some products and in others has an adverse effect on product quality. (e.g. fine wines)

Figure 5

Bottom Filling

The best way to minimize foaming is to immerse the end of the filling tube in the liquid during the fill cycle. This minimize the turbulence of the product during the fill cycle.

Both the vacuum and gravity filling principles can be used in conjunction with bottom filling. Bottom filling is used for filling fine red wines to minimize oxidation caused by agitation in the presence of air. The principle of operation of bottom filling is shown in figure 6.

Bottom filling is used when:
- "Fill height level" is desired
- Product is free flowing
- Product requires gentle handling

Figure 6.

Product level Sensing Devices
Product level sensing devices may be used to shut off a valve in the filling tube. This eliminates the necessity of a product return system. This level sensing may be accomplished either by sonic controls or measuring air pressure variances.

PISTON FILLERS
Straight Line type:
The product supply tank is located above a piston cylinder. The piston is mechanically driven in and out of the cylinder. A valve is located between the cylinder and the tank. This half-moon shaped valve rotates approximately 90° each cycle of the machine, which begins with the valve in a position connecting the product supply tank to the cylinder. While in this position, the piston of the cylinder draws back, creating a vacuum in the cylinder. With the cylinder filled and the cylinder in a stop position, the valve rotates 90°. This closes the former opening between the supply tank and the cylinder and opens an escape route from the cylinder through a filling tube. While the valve is in this position, the piston strokes forward, ejecting the product in the cylinder through the filling spout into the container.

The length of stroke of the piston is adjustable, allowing the volume of product drawn into the cylinder to be varied. The principle of operation of this type of filling is shown in figure 7.

These fillers can be for viscous products such as honey, peanut butter, creams and jams.

Units are available in hand crank single piston form up to 10 and 12 spout straight line automatic fillers.

Bottom up filling is usually a must on piston fillers to minimize air bubbles in the container.

Container feeding takes a variety of forms in straight line piston fillers.

- Containers are advanced at right angles to the spouts and the containers are moved to accomplish the bottom-up fill.

- Containers are advanced " in line" with the spouts and the container are moved to accomplish the bottom-up fill.
- Containers are advanced "in line" to a point in front of the spouts and then moved at right angles under the spouts, discharged at right angles to a point behind the spouts and then discharged "in line". Bottom-up is accomplished by moving the containers.
- Containers are continuously advanced "in line" with the filling spouts moving into the containers while they are moving and travelling with the containers during the fill cycle. Bottom-up fill is accomplished by the spouts moving into the container.

Figure 7.

ROTARY PISTON FILLERS:

The pistons are mounted vertically around a rotary continuous moving filling head. The piston passes under the product supply and moves down filling the cylinder. The cylinder continues to rotate. The end that was open to the product supply closes and the piston moves up in the cylinders. This discharges the product into the container through the filling spout. These are usually high speed machines - line speeds often exceeding 500 per minute. The machines are used for filling products such as motor oil, juices and apple sauce.

Piston filling is used when:
- Volume measure is desirable
- Constant head pressure cannot be maintained
- High fill time is desirable

METERING TYPE FILLERS

Single cycle system:

This type of equipment performs its function by turning on a positive displacement type pump. During the period the pump is operating, a measured amount of product is dispensed. This principle of stopping and starting a pump is suitable up to 60 cycles per minute.

The volume measure is determined by operating the pump for a set period of time.

The latest units of this type incorporate a pump drive through a gear reducer which is fitted with a secondary shaft on which a revolution counter is mounted. The pump is turned on and runs until the revolution counter turns it off when the present count is reached. In effect, we are counting revolutions of the pump rather than allowing it to pump against time: this results in closer accuracies than time control.

Containers can be hand fed or indexed automatically in time with the fill cycles.

Continuous Flow System:

The pump runs continuously directing its flow into a manifold. Under this manifold moves a rotary table equipped with a number of outlets or filling tubes. The faster the outlet passes under the manifold, the less product is dispensed through the filling tube. The slower it moves under the manifold, the more product is dispensed. The rotary table and the pump are driven from the same motor with a variable speed drive for the rotary disc. By changing the speed of the disc in

relationship to the speed of the pump, the volume of product can be adjusted. Very close accuracy of fill can be obtained. The container feed is similar to other rotary fillers in the way the container is indexed under the filling spouts.

Metering systems are used when:
- Volume measure is desired
- Constant head pressure can be maintained

Confusion may arise regarding liquid filling canned peas, beans, corn and soup. These may be considered liquids. However, this type of product is normally handled in two stages. Initially, the can is filled with a volumetric measure of the product and then the liquid is filled on a second station. The liquid filling is normally on an overflow or continuous flow basis where the overflow liquid is recovered and recirculated. The volumetric method is covered in the section on Dry product Fillers.

Factors to be considered when selecting a liquid filling system:

In reference to product, these may include such things as - solids in suspension, machine contact part compatibility, lubricating qualities of product, reaction to agitation or pumping, relationship to other liquids to be filled on the same machine, spillage effect on paints and metals and vapour loss.

In relation to the container such things as - internal shape in relation to liquid flow, neck size (inside diameter) fill height, exterior shape and its handling characteristics, stability (both empty and full), neck position on container (top, side, central, off centre, straight, cocked) and mechanical strength (push down on top, squeeze on sides).

Other general points of consideration - production speed required, location of liquid supply, operating atmosphere, electrical characteristics, air supply, frequency of size and product changeovers, cleanliness, government limitations (weights and measures or drug administration), floor space, ceiling height, floor loading, price.

DRY PRODUCT FILLERS

Volumetric fillers - Cup or Flask Measuring

This is the simplest and least expensive type of filling equipment for dry products. It incorporates a number of cylindrical shaped cups, each equipped with a trap door, rotating under a supply hopper. As the cup passes under the hopper it is filled with the product. The cylindrical cup then rotates to a position, where the cup is scraped or brushed level giving an even measured cupful. The cup then rotates, to the areas where the discharge spout is located. As the cup passes this area, the trap door opens and the measured product is discharged down the spout into the container. The cup then continues its rotation back around to the filling station and repeats the cycle. The principle of operation of volumetric filling is shown in figure 8.

A less expensive version of this machine consists of a disc on which the cups rotate and which contain the product in the cup until the discharge spout is reached

In this type of filling, accuracies are directly proportional to he product density. Therefore, the more consistent the density, the better are the accuracies obtained. Such products of reasonably consistent pellet size or grain size, such as frozen free-flowing vegetables or detergent powders, can be handled quite readily with volumetric filling and acceptable accuracies in weight may be obtained.

In order to help maintain a constant product density, the level of the product in the feed hopper should be constant.

Volumetric is used when:
- Product density is consistent
- Product is free-flowing

Figure 8.

Vacuum Filling

Fine powder products can be filled using the vacuum principle, which is basically the same as that used for liquids. The principle of operation of vacuum filling is shown in figure 9. A vacuum is drawn on the container and the product flows from the hopper at atmospheric pressure into the container which is at less than a atmospheric pressure. If a glass, plastic or metal container is used which will withstand a vacuum, then no additional problems occur. However, much of this type of product is marketed in a fiber board or paper cylindrical container which is porous and on which no vacuum should be pulled. To overcome this problem, a rigid shroud is placed over the container and the vacuum drawn on it. Thin wall containers that would collapse with normal vacuum are also used in this manner, e.g. metal. Plastic, fiber, or paper. Wide bodies containers with very small necks can readily be filled by vacuum. Vacuum filling is used for fine powders.

Figure 9.

Net Weight Filling

Net weight filling is widely used even though it represents the most expensive method of filling dry products. If a product is uniform in density, then volumetric filling which is relatively low in cost should be employed. If the product is inconstant in density, net weight scales are employed to give accurate weight measure.

Net weight filling is where the product is weighed outside its container and then discharged into it . The principle of operation of net weight filling is shown in figure 10.

The simplest type of net weight scale employs an equal arm lever. The weight is obtained simply by locating a weight or poise equal to the weight required. An equal weight of product is

required in the scale bucket to balance the beam. When the beam is balanced, the product is automatically discharged from the scale bucket into the container.

An automatic scale is quite simple in principle. The product is discharged from the end of a vibratory trough into the scale bucket. When the scale comes up to weight, the scale lever opens an electrical contact and the vibration moving the product is not constant in density. Therefore, even if a constant due to the amount of product suspended in the air at the time the electric vibrator is stopped. For this reason, most net weight scales employ a double vibratory trough system with the bulk of the product being placed in the net weight scale bucket for the net weight introduced through the “dribble” trough.

Both the “bulk” and “dribble” feeds are controlled by the scale balance, and as the scale bucket approaches the desired weight, it first trips out the bulk feed (at a weight slightly less than required). As it reaches the required weight, it trips out the smaller slower feeding “dribble” feed.

Some scales draw the “bulk” and “dribble” directly from the product hoper. Some employ a “feed” trough which pulls from the product supply and feeds both the “bulk” and “dribble” vibratory troughs. Other scales have two independent product sources drawing the ”dribble” from one and the “bulk” from the other. The latter system is employed to speed up the net weight system which is relatively slow when compared to other methods of filling. An auxiliary bulk scale bucket is filled through a preset weight, slightly below that required. As this auxiliary bucket, reaches the “bulk” weight setting, the bucket opens, discharging its contents into a net weight bucket which is fed by a “dribble” trough. The final weight is obtained by dribbling the product into the net weight bucket. While this ”dribble” process is taking place, the “bulk” fill for the next discharge is being weighed out in the bulk scale bucket. This speeds up the operation and allows for a dribble time as long as the bulk filling cycle. This results in better accuracies at higher speeds.

There are other weight sensing systems such as the electronic weight cell, air balance system and liquid displacement system which offer greater scale sensitivity and are able to detect very fine changes in weight . The weight sensing device, however, is not necessarily the whole answer for accurate weight. Net weight scale systems can only be as accurate as the flow control of the product to the weight bucket.

Net weight filling is used when:
- Product density is not constant
- Product is free-flowing

Figure 10.

Gross Weight Filling

Gross weight filling is the same as met weight filling except that no scale bucket is employed. The principle of operation of gross weight filling is shown in figure 11. The container itself acts as the bucket. “Bulk” and “dribble” feeding is employed to accomplish close weight accuracies and, as in net weighting, either a single or two product source can be employed, one for the bulk

and one for the dribble. One of the most common uses of gross for the bulk and one for the dribble. One of the most common uses of gross weight scales is for handling breakfast cereals: The carton with its liner is conveyed through a bulk weight station and then transferred to a dribble station where the weighing is completed. Final weight variation is affected by the inaccuracies in the weight of the containers, and is best suited where this factor is negligible. In some cases, the weight of containers cannot be controlled to close enough tolerances and, therefore, gross weighing cannot be employed.

A second reason for using gross weighing is with products which would tend bridge in the net weigh scale bucket. Some products will hang up in the scale bucket and not clear the bucket ready for the next weighting. This would mean that the product being discharged in the container is not of proper weight.

Gross weighing is used:
- When container weight is relatively constant
- With products which would bridge or stick in a scale bucket

Figure 11.

Auger Fillers

Auger filling is a volumetric form of product measure and, generally speaking auger fillers are used for products that are non-free flowing in nature. The principle of operation of auger filling is shown in figure 12.

This type of equipment consists of a supply hopper, and auger or "worm" running I an outer sleeve, and controls for operating the auger. The side walls of the hopper are funnelled to form the sleeve in which the auger runs, and the product is discharged from the end of the tube into the container.

The construction of the auger is determined by the characteristics of the product being filled and over 100 different design and size augers are used. A straight auger which is probably the most common, is suitable for products that do not tend to pack in the hopper. If the product should pack, it might stick to the side of the hopper and not fall into the auger flute: This would result in erratic fills. One answer to this problem is a slow speed agitator or feeder mechanism in the hopper which feeds the product to the auger ensuring a continuous flow. Some times a tapered auger is used with products which tend to pack. The larger flutes are capable of handling more product than the smaller flutes running in the sleeve. This also ensures the auger at the discharge point has a continuing supply of product.

Usually, augers are used for non-free flowing products, but free flowing products may be handled, giving the equipment more versatility. The fall through of a product which is free flowing in nature is prevented by a saucer or disc which is attached to the lower end of the auger, when it stops. As the auger spins, the centrifugal force throws the product off the disc. This type of auger incorporates a funnel which catches the product and directs it into the container.

The amount of product measured from am auger filler can be controlled either by a time cycle starting and stopping the auger or, for better accuracy, by counting the revolutions of the auger.

Packer augers are used on light powder products tending to incorporate air. These products must be packed into their containers. To achieve this, the standard auger is equipped with a former which fits over the auger tube and conforms to the dimensions of the opening on the container. The container is placed on a counter-balanced platform. With the container in place, the auger is turned on by the operator and continues to run, packing the products into the container and pushing the container down away from the discharge end of the auger tube. This operation continues until the counter-balanced platform reaches a preset position and the auger is stopped. Products such as whitewash are handled in this manner.

Auger fillers are usually employed with non-free flowing powders of a constant density. Products which do not constant density, however, can be filled by auger. Here, the container is placed on a scale platform and when the container has been filled to a present weight, a detector switch turns it off. This offers a gross weight type of filling.

Auger fillers are used where:
- Product is not free flowing
- Product is of constant density
- Packing type fill is required

Figure 12.

COUNTING

Some products require an exact number of discrete pieces in the package. Nuts and bolts, tablets, and sometimes candy products are marketed declaring the number of units in the package. There are four ways commonly used to count product.

Electric Eye Counting:

Counting of the product is done by electric eye. The item is fed by means of a vibratory bowl feeder, belt, or some other means of stringing out the product past an electric eye scanner. As each piece falls past the scanner, it is recorded. Usually, the discharge beyond the electric eye scanner is diverted to the waiting container. On the completion of the count, the gate diverting the product to a particular container moves and directs the product into a second container placed in position to receive the product. This type of counting is used on some hardware items and tablets where versatility and quick change from one product to another is a necessity.

Perforated disc:

A disc type counting mechanism is used for tablets, capsules and some other items. This is a simple mechanism incorporating a disc manufactured from plastic or wood which is drilled out, allowing room for an individual item to locate as the disc revolves over a fixed plate. The count required is obtained by placing groups of holes of the correct count around the disc and as this group of holes rotates by the product supply hopper, one of each item falls into the respective hole. The pattern of filled holes then rotates by a discharge chute in the fixed plate where these

items fall through the chute into the container. This is a simple, inexpensive method of counting but cannot guarantee a count as one or more holes may not fill.

Chutes or Channels:
The most popular machine for high speed counting of tablets feds the product from a hopper down a series of chutes or channels. The diameter of the tablet or pill is normally consistent and, therefore by multiplying this dimension by the number of pills required a measured row of tablets may be controlled and discharged to a chute filling the container. Where a larger count is required, three, four or five pre-measured lengths of tablets in their respective chutes may be released one after the other, forming a long line of tablets giving counts of 100 or more per dump. This method is used to handle items such as headache tablets and other high volume tablet volume tablet products.

The latest high speed tablet counting equipment incorporates a rotary bottle feeding principle with a number of counting heads mounted on a rotary turn-table. The count is performed and automatically released into the container during its filling cycle.

Straight line tablet counters (units where the bottles stop on their conveyor during the fill cycle) normally employ a girl who acts as an inspector to ensure that the chutes of the tablet filler are all completely filled before tripping the mechanism releasing the count into each bottle. The bottles are normally indexed automatically, leaving the operator complete time to inspect the tablets looking for such things as 'capping" and broken tablets.

Orientation devices:
Items such as screws, flat washers, nuts and bolts are counted on machines which either tumble or vibrate mass of product in the hopper in a manner which allows some of the items to locate in a track leading out of the hopper. The items caught in the track move down the track either by vibration, gravity or a combination of both, to the counting station. Here a group is released (in the same manner as tablet counting machines) by holding the items above a certain point and releasing those below, allowing them to fall into the container.

PACKAGE MAKING EQUIPMENT

Most packages are fabricated to some degree in the plants of suppliers, e.g. glass bottles and jars; metal cans; rigid and semi rigid plastic containers; printed and scored cartons and corrugated cases; preformed paper or film bags. There are certain operations, however, which must be accomplished in the user plants. These include capping; clinching; forming and sealing cartons and cases; forming and sealing bags; overwraping; labeling and certain special operations such as unscrambling rigid containers or inserting cotton in tablet bottles.

Bag Top Closing Equipment
Speeds of 8-10 bags per minute – a jaw type sealer is employed. On this equipment the bag top is placed between the sealer jaws. The jaws are closer by the operator and the bag sealed either by direct heat and pressure on all heat seal coated materials or by the thermal method in the case of plastic films.

Speeds from 10-60 can be accomplished by using a rotary type sealer where the operator feeds the top of the bag into the sealer. The supporting conveyor moving at the same speed as the sealing unit supports the bag during the sealing operation.

If a bag top or tent label is required this can be done on either a jaw sealer or a rotary type sealer specially designed for this work.

Sometimes glued or stitched closures are used and a combination of heat sealing and stitching may be accomplished on a rotary type sealer.

FORM - FILL – SEAL MACHINES

Vertical

Pillow style bags are formed from a single web which is drawn over a forming shoulder around a hollow tube. A side seam is formed using appropriate sealing mechanisms and web constructions.

The side sealed web is gripped by cross seal jaws at the bottom of the tube and is pulled down to the required length and sealed. Simultaneously, the pouch is filled through the hollow tube. Finally, a cut is made along the center of the cross seal to form the top seal of the previously filled bag and the bottom seal of the bag being filled. Tetrapacks are formed by turning the cross seal jaws 90˚ for successive seals.

Heat sealing mechanisms can handle practically any type of heat sealable film or laminate. Sometimes Teflon cloth is used on the surface of the heating unit in order to obtain satisfactory release of the sealed materials from the heating surface. Some machines are designed for automatic bag to labeling; price marking; code date imprinting; gusseting; perforating strip packs; gas flushing or other special features. Registration controls are used as required.

4-side seal pouches may be formed by using two webs to form the package. Two side sealing units are used on this type of equipment. Different materials may be used for the face and the back of the package.

Many types of filling heads are used on vertical form-fill-seal machines depending on the characteristics of the solid or liquid product which is being packaged.

Horizontal

This type of machine draws a web from a roll and folds it in half. A series of vertical seals are made while the foled web is traveling horizontally, leaving the unsealed side at the top. The bag is then opened, filled, the top sealed and the individual packages cut and discharged; or side sealed, cut, opened, filled, top sealed and discharged. This procedure takes place on an intermittent machine, at 50 to 60 per minute, and 100 per minute with double filling mechanisms.

High speed machines operate continuously up to 500 per minute.

Horizontal Integrated with Cartoner

Pouches are made from commercial heat sealing laminated materials fed from a roll. Sealing methods such as impulse, di-electric, and ultrasonic, have permitted use of monofilms. The web is fully formed, sides sealed (often with individual pattern registration), cut off, top opened, filled, top sealed, and counted, then stacked and inserted into a carton automatically. Filling is achieved by rotary volumetric flask or auger discharge into "bottoms up" funnels, then into the pouch to eliminate dusty conditions. The adjustable flasks or continuous auger-type filling heads can be used singly or in combination. This produces either a three or four side seal package with or without bottom gusset.

AUTOMATIC BAG SELECTING – FILLING – SEALING

Other equipment is available that uses pre-formed bags which are automatically drawn from a magazine, opened, filled, sealed, and discharged. This type of machine can be filled with either heat-sealing or glue-sealing of the bag tops.

Some items packaged in this manner include seeds in envelopes or sugar and flour in one pound to five pound bags.

UNIT PACKAGING

This refers to the many machines which employ a single or double web feed to form a package or group of packages by controlling the cut off.

Some tablets are marketed in an individual pocket, and sold in groups of two to twelve. Tablets and lollipops, are good examples of multiple unit packaging. Hardware items, such as hinges, and switch plates are examples of individual unit packaging.

Liquid packaging is accomplished on the unit packaging equipment, giving individual servings of such items as catsup, soya sauce, and liquid shampoo.

CARTON – FORMING AND SEALING (Glued Type)

Semi-automatic

An operator passes the bottom long flaps of the cartons through a glue-roller and folds the bottom flaps into place. The bottom-sealed carton is then placed in a compression belt and as it comes from the end of the compression belt it is filled by means of a semi-automatic filler suited to the product. The filled container is then passed to a second operator, who applies glue to the inside long flap of the top and folds the top flaps into position for final sealing in a compression section. Often the carton is filled directly from the bottom-sealing operation with the product weight holding the bottom flaps in place while the top flaps are being closed; bottom and top seals are set in the final compression belt.

Automatic – Forming – Filling – sealing

There are two types of bottom sealers. The more expensive type has forming blocks to support the carton during compression. The end flaps are glued and pressure is applied while the cartons are held on the blocks. This results in positive seals. Cartons with previously glued side seams are opened, folded 180˚ to ensure a square carton, and positioned on the block. Sometimes

cartons are received in the flat without glued side seams; these are folded around the mandrel and the side seam is glued before the bottom seal is effected.

The second type does not employ a block to support the carton during compression. The carton is opened and the bottom flaps are glued and folded before the carton is passed between a creaser roller; this ensures that the small flaps have made contact with the long outside flaps and eliminates the spring back of the long flaps by breaking the fibres along the score lines.

All top sealers are basically the same as this latter type since no block can be inserted into the closed carton. It is essential that the machinery manufacturers design the machine to ensure that the inside small flaps have made contact with the glue-coated long outside flaps.

Cartoning Equipment

The modern high speed fully automatic carton former-sealer often known as a packager provides for all operations on one continuous motion machine. Cartons are bulk loaded and automatically fed, formed , bottom glued, filled, top glued and compressed. The product filling method may be volumetric, net weighing, gross weighing or auger feed on the same basic machine. Tuck closing, standard gluing, or hot met may be used. Product pour spouts, premium inserters and code daters operate at full carton speed.

There are semi-automatic cartooning machines which set up the bottom of the carton only. Others set up the bottom of the carton and allow for hand filling of the product, after which they close the top flaps of the cartons. Cost determines the particular units choice.

Double Package Making-lined Carton

This is an automatic machine for producing a double package from a cut and scored carton blank and lining materials fed from a roll. The lining is cut to size and formed on a block or “mandrel” on a rotating turret to make the inner bag; the block is indexed to subsequent stations to form the carton shell around the liner and block. This tightly lined package offers maximum protection for the product with space for complete fill.

Most of the waxed papers, glassiness or laminated stocks can be used as lining materials with glue or heat seals or combinations of both. The lining mechanism can be used to make a square bottom bag separately, while the carton unit can also be used to make and set up a glued or tucked carton.

Most cereals dessert powders and many types of biscuits and cookies have been packaged in double packages for many years.

Case Opening Packaging and Sealing

There are actually four stages in this operation:

- Opening the case
- Sealing the bottom
- Loading the case
- Sealing the top

There are 64 different combinations possible for effecting the above operations since each step can be performed either manually or automatically, using glue, tape or staples.

The simplest method is hand sealing the bottom of the case with tape or staples, hand loading, and hand sealing the top with either tape, staples, or glue. The operation can be improved by automatically sealing the top of the case.

Most glass containers are shipped by the glass manufacturer in a reshipper which has the bottom of the case already sealed. This means that the cases, after being emptied, will be reloaded with the filled glass and only top sealing is necessary.

In a casing operation the most common method of loading and sealing is the horn type case packer. The operator sets up the case over the horn; the cartons which have been automatically accumulated are then loaded through the horn into the case which is then lowered 90˚ to a horizontal position. The filled but unsealed carton is conveyed to an automatic case sealer where top and bottom flaps are sealed.

A fully automatic operation is available where the cases are automatically removed from a hopper opened or formed, loaded and sealed both ends.

Another method is used where the product due to its nature must be hand packed. In this operation the case is set up and loaded by hand and is then fed by conveyor to an automatic sealing machine using either glue, tape or staples.

Automatic sealing equipment is available using either glue sealing, stapling, or taping to run a single size container on a line or to run random sizes of containers. The random size machine automatically senses and adjusts for the construction to avoid high maintenance costs.

Equipment is available which feeds a slotted and scored corrugated blank from a hopper, accumulates and feeds a pattern of packages, forms the blank around the pattern of the packages and glues the flaps to present a finished shipping container.

OVERWRAPPING

Overwrapping is the application of a flexible envelope around the unsupported product or the carrier in which the product is contained. It may be used for protection of the product, appearance, clarity, multiple seal packs or as a replacement for a conventional over packer.

Most overwraps use plastic film materials but paper, foils and laminates are used extensively. Heat seals, adhesive seals and twist closured may be used.

Multiple packs use some supporting device as a general rule; flat boards, u-boards, trays or cartons are types which are most common. In some cases however, cartons or bags may be accumulated manually or automatically and should be based on production as well as labour costs along with the effectiveness of the support during distribution.

Stretch and shrink films used extensively and special wrapping machines have been developed for the use of these materials. Standard wrappers can be modified to run shrink films by installing static eliminators, controlling the heat seal range within minimum limits, and coating the heat sealing elements with Teflon to ensure effective release. Generally, however, modified machines require considerable maintenance: it is preferable to use machines designed for a specific purpose.

Semi-Automatic Overwrappers

Several types of semi-automatic machines are available for low volume output. This type of equipment requires some manipulation of the product or packaging materials by the operators. Pressure heat sealers and impulse heat sealers are used for the appropriate materials. The L-type bar sealers use impulse sealing on a folded sheet; the L-bar seals across the sheet to make a bottom and top seal and along the free edges to make a side seam. Usually the product is positioned manually and the operator uses a foot switch to control the motion of the machine

Automatic Wraparound Types

The automatic wraparound machine selects and cuts a piece of material from a roll and applies it to the package, making all folds necessary and sealing by means of heat or adhesive. Accurate registration of printed designs is available as required. Folds effected by pushing, elevating or lowering the product through stationary fold dormers or by the action of moving formers on a stationary package. Reasonably tight wraps are obtained with these machines if the product has consistent dimensions. Some machines are available which adjust to slight changes in product dimensions.

Continuous Motion Horizontal Tube Wrappers

Unit items such as bakery products and donuts, chocolates bars, and sandwiches must be overwrapped by a some what different method to provide high speed economies required for this type of packaging. This is accomplished by forming the web of film around the products to create a tube with a seal along the bottom or top. This tube of film then travels along with the products to a rotating head which moves down in between the products effecting a seal and at the same time cutting the film between each package. This continuous motion horizontal machine provides high speed operation up to 200 packs per minute. It produces a pillow style package rather than a folded wrap as previously described.

Shrink Tunnels

Tight wraps are obtained by using heat shrinkable film on a conventional wrapper with modifications as required and passing the package or bundle through a shrink tunnel under controlled conditions. Temperature, air currents and time I the tunnel are controlling factors.

UNSCRAMBLERS

There are two basic types of bottle unscrambling. The most inexpensive is the rotary unscrambler which is effective for round or cylindrical containers. These machines employ a dump platform from which the bottle are transferred to the rotary disc where they are ploughed

against the outside edge of the disc by a series of guide rails, allowing them to single out onto the take-away conveyor.

An attachment is offered to make the unit suitable for some rectangular and square containers which overcomes the problem of the containers jamming as they are single filed, simply by allowing them to jam and breaking the jam.

Another type of unscrambler available, but not commonly seen, employs a series of flat bed conveyor chains increasing in speed as they move away from the discharge conveyor towards the bottle filling station. A plough or guide bar directs the container into the next high speed until such time as the units are single filed.

The straight bed type is the most widely used and can feed glass, metal or plastic containers at approximately 30 to 300 per minute. Incoming containers are packed upside down in the shipping cases and dumped by one or two operators on a resilient stationary bed. Before the packing case is removed, it is slid forward, moving the containers onto a wide indexing belt. This belt indexes under stationary vanes a little more than one container diameter at a time. The containers move gradually forward in orderly single lines side to side to the front of the machine, where they are released by a cammed retainer bar system onto the line conveyor moving at right angles to the feeder feed. A deadplate one container wide is placed just before the line conveyor position and this, in conjunction with the retainer bar timing, allows only one row or "front" of containers to move away per cycle.

CAPPING EQUIPMENT

Simple hand chucks for cap tightening are available and in wide use throughtout the industry for low speed production and short varied runs. Ceiling or frame hung motorized flexible shaft cap tighteners are also available. There are many variations of these cap tighteners, but all require that the cap be placed on the neck by hand. Cap tighteners are used in the "1 to 24" per minute range. Fully automatic cappers with automatic cap and container feeds are available in single head 60 per minute, in-line or rotary, and two, four, six and eight head rotary models. Speeds covered by the multiple head rotary machines range from 60 to 300 per minute. All of the above are for use with screw or lug screw type caps.

Another principle employed for high speed capping which has become very popular in recent years is a continuous motion machine which allows the container to select its own cap from the cap. As the cap is selected, it is held squarely over the bottle by means of a stabilizer, and with the cap held in this position the container passes between a series of rotating discs. In passing through these discs, the cap is spun onto the container with last set of tightening discs establishing the take off torque required. These high speed models have a range of from 60-300 per minute containers.

Automatic cappers consist of four groups of mechanism, a cap sorting feed, a centre section or cap chute, the cap pick-off and applicator section, and container feed and gripping mechanisms. The cap feed orients bulk caps usually through an inclined or vertical disc mechanism and directs

these caps to the cap chute which feeds them in an oriented single line to a pick-off point. The mechanisms for cap sorting are many and varied, usually especially suited to the particular cap or range of caps being handled. They operate, generally, by the process of elimination. As the caps are manipulated in a certain way (i.e. on an inclined rotating plate) a percentage of the total will be located in the proper manner. It then remains only to remove those not located properly. This is done by air jets, mechanical parts or gravity whichever suits the particular cap. A simple screw cap requires relatively little mechanism for sorting; compound shapes and tabs, etc., complicate the process enormously.

The caps are picked off the cap chute and directed to the applicator chuck by a mechanical transfer arm or in some cases by the container neck itself. Many configurations of chucks are available which utilize mechanical or expanding part gripping of the cap. There are many different methods used to obtain proper torque control and cap gripping. Container feed is accomplished by a "feed screw" or "starwheel" or both, and the containers are mechanically gripped to stop them from turning as the cap is being applied. Plastic containers of some types present a difficult problem in so far as they must be supported mechanically as they are gripped; this is necessary since they tend to collapse; pushing liquid out of the neck before the cap can be applied.

Steam Capping

Where vacuum capping is required, it is normally on a continuous motion straight line machine where the container selects the cap from the cap chute. In this operation, pre-heated steam is injected between the cap and the container as the cap is picked up by the container. The cap is normally tightened by belts on this type of equipment.

PLASTIC FITMENT APPLICATORS

These machines are derivative of the capping equipment discussed above, and apply the new types of plastics fitments which are either in place of caps or sometimws take the form of an internal fitment such as for shaker neck ciontainers or spice containers. These fitment machines are all automatic in operation, with an individual specially designed model being required for each different style of fitment.

LABELLING

Labellers are available in many sizes and speeds. These include the hand fed label gluer, where the operator feeds one label at a time through a set of glue rollers, picks it up on the other side and applies it manually to the bottle (maximum 15 per minute). The semi-automatic labeller operator feeds a container and activates the machine which picks a label off a stack, gluess it and applies it, (maximum 50 per minute). Automatic labellers are divided into two types, -- those which apply glue to the container, then apply the label, and those which apply the glue to the label, and then apply the label.

Labels may be applied to front only, back only, front and back, partial wrap around, full wrap around, neck, and shoulder. Automatic labellers are available in "In-Line" or "Rotary" models,

both using a series of function stations. Normally there will be an indexing or positive feed device to ensure proper positioning of the container, then a glue application station (for label or glued container), a label application station (for either label to glued container or glued label to container), possibly a wiping station, and a press station.

Automatic labellers are available to cover a speed range of 60 to 300 per minute and in multiple machine arrangements to go faster. Special types such as container "roll through" for round containers and partial or full wraparound labels and stripp stamp liquor labellers are in wide use where the situation demands them. The container materials, its curve, taper and general shape as well as the label material, size, shape, arrangements and glue requirements must be carefully examined in conjunction with the these machines before a recommendation can be made.

COTTONERS

These machines are used in the tablet packaging field for placing a plug of cotton in the top of the container to prevent the pills from moving while the bottle is transported.

The semi-automatic and automatic machines are exactly the same in their stuffing action with the only difference being whether the bottle is fed to the machine by hand or is automatically indexed through the equipment.

The machine selects a preset length of cotton from a coil placed beside the machine and either cuts or breaks a length of cotton, literally stuffing it into the container. It is important that no wick ends protrude outside the container after the capping operation, since these would allow the passage of moisture into the container, damaging the pills.

The semi-automatic machine operator presents the containers to the machine and in placing it in its location under the stuffing mechanism depresses a micro-switch, signaling the machine to complete one cycle.

If the machines are fed automatically the containers are indexed either by mechanical fingers or air index mechanisms to hold the container in its position under the stuffing mechanism during the cycle of the machine; the stuffed bottle is automatically ejected along the take away conveyor.

SPECIAL EQUIPMENT AND TIE-IN UNITS

The integration of packaging line machines to accomplish the desired automatic or semi-automatic operation requires specially designed components such as conveyors, indexing units, line dividers, special loading attachments, collating units or special types of packaging machines which apply specifical to a single packaging line operation.

CASE UNLOADING

This function may be performed by hand unloading up to speeds of 30 or 40 per minute, by case dumping in conjunction with the loading table portion of a container feed up to seeds of 120 to 150 per minute with one operator and up to approximately 300 per minute with two operators, or by automatic case unloading on single purpose or specialized lines. Glass, metal, plastic, and fibre containers may be handled in any of the above ways.

CLEANING

Container cleaning is an important but often forgotten segment of the line. Liquid, combination liquid-steam or air cleaning may be used. Liquid or liquid-steam cleaning is generally used on containers being reused and is termed washing or rinsing rather than cleaning. A wide variation of 30 to 600 per minute machines are available.

Air cleaning is universally used in the food industry on new non-returnable containers, and consists of a blast of high pressure air from an inserted nozzle in conjunction with a vacuum draw off for the used air and residue. To be effective at all, the container must be inverted during the cleaning cycle. Available machines range from 15 per minute manually operated units to rotary 300 per minute units. Also available are in-line high speed 300 to 500 minute units using rubber tires or belts to convey the containers through the machine.

Air cleaners are designed to remove some, if not all, manufacturing residue (glass, plastic shavings), glass chips and carton dust and general dirt which accumulates in the container during manufacture, storage, shipment and handling previous to filling.

COUNTING FILLERS

Type	Product	Advantages	Limitations
Electric eye	Hardware items tablets	Accuracy speed, quick change	Not suitable for nuts, washers, capsules etc. where double counting will occur.
Disc	Nuts, bolts, washers, tablets	Simplicity	No guarantee of accuracy
Column	Tablets, pills etc., of uniform size	High speed, accuracy, gentle handling	Size of particles must be consistent
Track	Screws, washers, nuts, bolts, etc.	High speed, accuracy	Size of particles must be consistent. Product must be sturdy enough to with stand vibration or tumbling

LIQUID FILLERS

Type	Product	Advantages	Limitations
Fill Height Level			
Vacuum	free flowing, non foaming	flexibility, low cost, speed	rigid containers only unless shrouds are used.
Gravity, top filling	free flowing, foaming	simple, low cost	speed limitations.
Gravity, bottom filling	free flowing, very foamy	fairly simple, low cost	speed limitations, fill height control problems.
Non-overflow-sensing-control-pressure or gravity	free flowing, very foamy	accurate, no overflow, no internal pressure to containers suitable for semi-rigid containers	higher cost due to sensing controls.
Pressure Filling			
Non-overflow-sensing control	viscous	same as above	
Metering positive displacement pump	viscous	accuracy	speed limitations) no fill
Rotary pump and revolution control	viscous	accuracy, higher speeds	requires adjusting)height
Gross weighing	viscous	accuracy	speed limitations)control
Volumetric pressure (rotary disc-pump speed ratio)	viscous	seed, low cost	uneven fill height, requires adjusting vacuum draw-off control.
Piston Filling			
Straight line	viscous-creams, jams	volume control	no fill height level control.
Rotary	viscous-creams, jams	high speed, volume control	no fill height level control.
Liquid - solid	soup, canned peas, corn, beans		no fill height level control.

DRY PRODUCT FILLERS

Type	Product	Advantages	Limitations
Volumetric			
Flask Measuring	free flowing powders, pellets etc. with consistent density	Low cost	Density control of product
Vibrators	free flowing materials, abrasives, heterogeneous mixes, bits	Low cost, speed flexible range of materials	Weight control
Vacuum	free flowing powders into rigid containers	High speed, fill height control, moderate cost	Weight control, density control, variation in capacity of containers
Vacuum with shroud	free flowing containers with semi-rigid containers	Same as above	Same as above
Volumetric with Net Weight Monitor Flask		Adjustments for changes in product density, lower cost and higher speeds than net weighing	Some leg in making adjustments

DRY PRODUCT FILLERS

Type	Product	Advantages	Limitations
Net weighing			
Balance Beam Scale	variable density products free flowing	weight control	low speed, max.20 per minute, higher costs, dust control, maintenance of knife edges
Air Balance Scale	same as above	weigh control no knife edges	maximum 25 per minute
Balance Beam Scale (vibrate off over-fill)	uniform powders, granules	accurate weight control	slow recirculation of excess product
Liquid Displacement Scale	free flowing products into rigid or semi-rigid containers	direct weighing to tared container, fairly accurate	relatively slow
Electronic Scale	variable density free flowing products	accuracy, long life	maximum 30 per minute
Gross Weight Filling	free flowing products which bridge or require compacting	fill direct to container: scale buckets eliminated	variation in tare weights

DRY PRODUCT FILLERS

Type	Product	Advantages	Limitations
Auger Fillers			
Straight Tube	powders, granules (free flowing with disc at discharge)	suitable for products which pack or bridge reasonable speed	requires uniform density product and controlled feed
Tapered Tube	products which tend to bridge or pack	same as above but more effective	same as above
Bottom Fill to Container	light, dusty powders	inhabits dusting and compacts product into container	same as above usually slow speed
Split system	powders, granules	continuous motion allows higher speeds; more accuracy than stop-start operations	receiving mechanism must be well designed to prevent spillage and control weights
Gross Weigher	variable density powders and granules	gross weighs variable density products which tend to bridge or pack	slow speeds; accuracy only within tare weight variation

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Chapter - 8
PLANT LOCATION AND LAYOUT

Necessity:

There could be several reasons why a firm should look for additional or alternate locations and sites. These are:

- To establish a new venture
- Expansion of existing business
- Significant changes in the existing demand, supply and market locations
- Significant changes in cost and availability of inputs such as raw materials, labour etc.
- Company policy on diversification and change of working climate, etc.
- Government policy of dispersing industry away from cities and/ or emphasis on locating industry in green field areas, etc.

The following options are open to the management:

- Make or buy decision
- Sub — contract instead of expansion
- Expand the existing plant instead of building a new one Build a
- new plant instead of shifting the existing one Dispose off the
- existing plant and build a new one

Plant location is important because of the following:

- Location influences plant layout and facilities needed Location influences capital investment and operating costs

Sequence of operating of siting has the following phases:

Phase I: Plant location analysis

Phase Il: Site selection process

PLANT LOCATION ANALYSIS:

Location analysis follows a preliminary survey conducted to establish feasibility of location. This survey is needed to study geographic location, collect relevant data and other information and hold discussions with people concerned by visiting the location.

Having collected the relevant data, the next step is the analysis of data. The main objective is

to reduce total cost of project both in terms of capital and operation. Depending on the type and nature of plant, specific requirements are found necessary. For example, abundant supply of water is essential for a location selected for setting up nuclear reactors for cooling purposes. In this analysis, demographic, geographic and climatic considerations are equally relevant as the availability of inputs like labour and raw materials. Other considerations are facilities such as transportation, market, communication, electricity, etc. Both tangible and intangible benefits are analysed here. Both subjective and objective considerations are given weightage in this analysis. Some such factors considered are:

- Availability of land (present & future)
- Cost of land & land development, building, etc
- Availability of labour, raw material, etc., and cost thereof
- Availability of ready market and distance
- Present and future demand forecast
- Present and future competition
- Availability of communication facilities = road, rail, air, port, water ways, post, telephones
- Infrastructure = electricity, water, banking, finance
- Waste disposal, effluent treatment, environmental problems
- Soil characteristics = load bearing capacity, drainage capacity
- Government support, grant, subsidy, tax structure
- Union activities and political influences
- Availability of township & recreational facilities
- Availability of residential & office accommodation (rental?)
- Demographic factors = population, trained manpower, educational institution, standard of living, income level, etc
- Climatic considerations = rainfall, temp, RI-I, dust count, prone to flood?
  , water table level, etc
- Security, fire protection, police force, etc
- Future expansion possibilities
- Social acceptability of project & attitude of people towards project which is to be set up in their place

SITE SELECTION PROCESS:

Selection of site is an important step requiring the assistance of experts. Normally an operation research group, consisting of various experts with considerable knowledge and sufficient seniority, is formed. Since the Central and State Governments are also involved they also would like to associate with this committee.

The major pitfall in site selection is the influence of local politicians and officials. They would bring all sorts of pressure in locating plants in their own region. This is especially true in locating public sector/ state sector plants. In worst cases, all techno-economic considerations are generally overlooked for political expediency and pressure tactics. This calls for extra precaution and safeguard. The economic viability of a project gets affected by defective selection of site. Following are the factors specific to site selection:

Specific requirement for the manufacturing process such as availability of electricity, water, etc., Land availability for future expansion. Normally, depending on the built in area, the land required will be in the ration of 1:5.

Cost economics:

Main consideration is to minimize the total cost which consists of capital cost operating cost and distribution cost. The location of the plant determines all the three as is evident from the following.

Capital cost consists of cost of land, land development, building and services like air conditioning, effluent disposal, environmental protection measures, and infrastructural facilities such as water, electricity, township, quarters, etc. In addition, in-house facilities depend on its availability of otherwise of such facilities in the selected location. Examples are availability of local plating line, automobile service station, small scale industries, etc. If these are not available, in-house facilities are to be set up within the plant itself resulting in additional capital cost of the project.

Operating cost consists of cost of capital, overhead and depreciation on capital (fixed cost), cost of materials, labour and cost of working capital (variable cost). These have direct bearing on the availability and cost of labour and raw materials in the location selected.

Ditribution cost is transportation and sales cost. The transportation and sales cost naturally depends on the cost of communication such as rail/ road/ air transport, telex, telephone and postage expenses, tax expenses, etc. This again depends on the distance of the Plant from the market.

Capacity Planning and Economies of Scale

a) Single Plant Location: The interrelationship between the above costs and plant capacities are shown in Fig. 1 and Fig. 2. We find that the operating cost goes down as capacity increases. Profitable operation takes place

above break-even point (BE). However, distribution cost shows a tendency of rising as the volume goes up. Hence after certain value the rise of distribution cost more than offsets the fall of operating cost resulting in a rise

in the total cost which might become higher than revenue at break-down point (BD). This shows that the plant has reached beyond the economies of scale, clearly indicating the necessity for additional plants.

b) Multiple plant location: In Fig. 2, the relations between the total cost (variable cost + fixed costs) and volume of production are shown for various locations which will enable management to carry out a BE analysis or

decide on the optimum capacity at such locations. There are three BE points identified for three locations respectively. One of the main reasons for multiple location is to reduce the distribution cost.

c) Cost Economics of Multiple Plant Location: In Fig 1, we have seen that there is an 'economy of scale' for each plant beyond which distribution cost goes up making further increase in volume of business counterproductive.

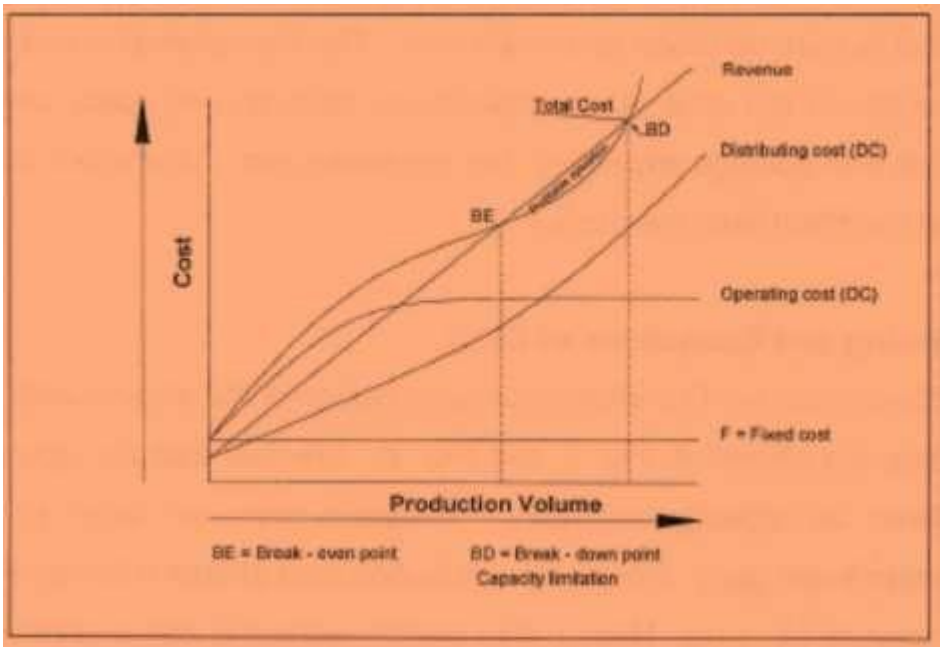

Fig. 1. Economies of Scale – Single Plant Layout

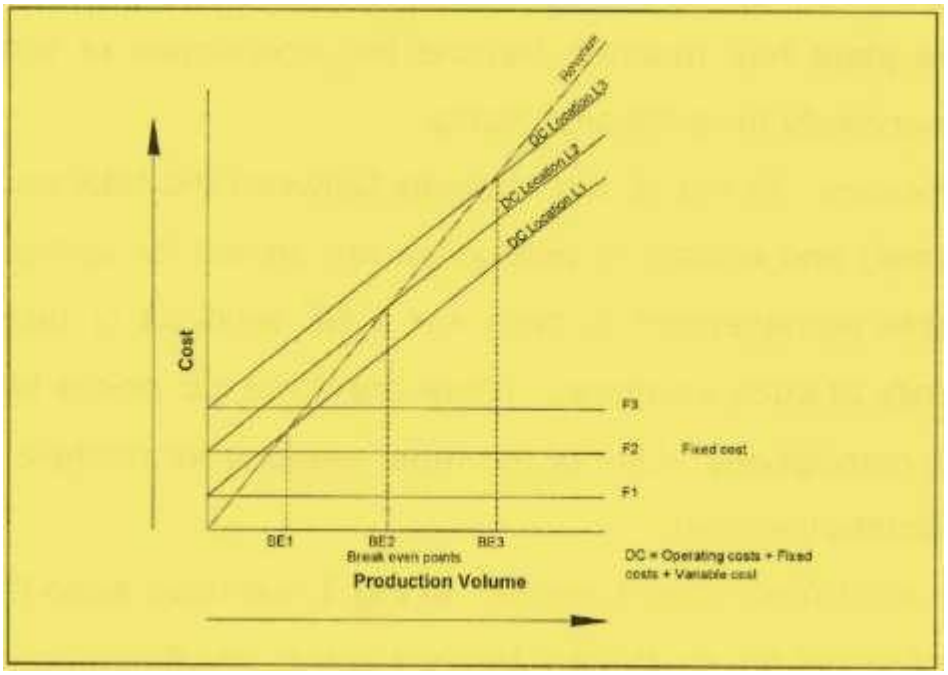

Fig. 2. Economies of Scale – Multiple Location

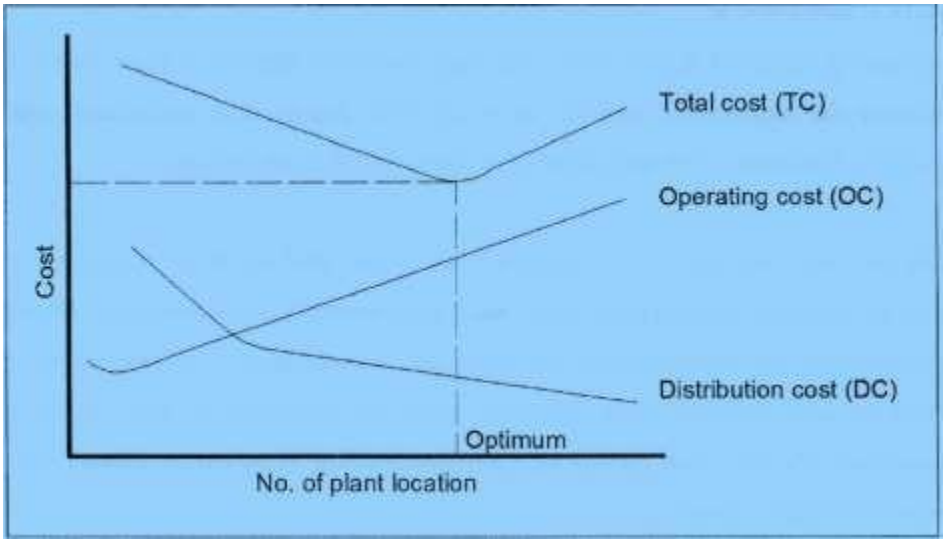

Fig. 3. Economies of Scale – Multiple plant location (Overall)

In multiple plant location in Fig 2, breakeven is fixed depending on the operating cost (fixed + variable cost). Considering the distribution cost, the break-down point is determined beyond which economics of operation prevents further expansion. Lower the break-even point, larger the area of profitable operations. By having plants at multiple locations, no doubt the distribution cost comes down. However, at the same time, the operating cost goes up mainly because of increase in fixed cost. This therefore leads us to believe there is an optimum level even in the number of locations. This is depicted in Fig. 3.

Factory Building and Services

Factor analysis:

The following factors are considered in the design and construction of buildings:

- Location and nature of terrain.
- Plant layout and space requirement. Type of
- product and processes.
- Flexibility and future expansion possibilities.
- Working environment like lighting, heating, air conditioning, ventilation, etc.
- Service facilities like fire protection, environment protection, effluent treatment, etc.
- Infrastructural facilities like water, electricity, compressed air, etc.
- Consultants, collaborators and contractors
- Appearance and aesthetice Cost of construction

PLANT LAYOUT

After having decided the location and site, the next step is to draw out a floor plan indicating the location of various work centres, plants and associated offices, and supporting facilities. The definition of a plant layout is as follows:

The judicious selection of the location of the plants and machines should be in such a way to facilitate uninterrupted and quick movements of input materials through predetermined cycle of operations till these are transformed as outputs in the form of products and services with minimum material management and handling, with maximum efficiency and quality of operation leading to minimum overall cost of the entire operations/processes.

Factors affecting plant layout

Plant layout is an important step. This is a planning function in management. There is a tendency to neglect this area or entrust this job to inexperienced persons leading to high operating costs and lack of flexibility. These factors are classified under two broad headings: external factors and internal factors.

External factors.

- External transportation (rail/ road/ water) Receiving
- operations (unloading, stores, etc) Packaging
- operations
- Storage operations
- Despatching operations (shipping) Offices/
- support functions Internal factors:
- Type of product & process
- Volume of production Quality
- Type of operation (continuous/ batch)
- Design of building (single floor, multi-storeyed, space, etc) Personnel (type,
- number, level of education, nature of work, etc) Material handling equipment
- Type of plant and machine

Classification of Production:

There are four kinds of production: job, batch, mass and flow production.

Job production:

These are products manufactured to meet the special requirement of customers for large projects, e.g., ship building, large engineering construction, etc. These are special type and are one — time jobs.

Batch production:

This involves manufacturing a number of identical products in batches to meet specific one — time requirement or periodic requirements.

Continuous production:

This involves specialised manufacture of a large quantity of identical items and it is of two types: mass production and flow production.

In mass production, a large number of identical products (standardised) are produced through fully automated product lines. In a process line, the plant or work centre is capable of giving out a large number of similar products or processes. Example is that of an auto lathe or a ribbon mixer or pulverizer. In this case the work centre is capable of accepting a different

product for mass production as long as the process remains the same.

In flow production, a number of work centres are arranged in a particular sequence and the products pass from one work centre to another. This is also a kind of mass production but the line is not fully automatic. It could be semi — automatic or even manual. Thus we find mass production need not be a flow production whereas flow production necessarily has to be a mass production.

Types of layout

Layout can be classified into four types:

1. Fixed position layout
2. Process layout
3. Product layout
4. Combined layout

Fixed position layout:

In this type of layout, the major equipment remains in a fixed place and all tools, machines, men and material are brought to it. The job is completed without the major equipment leaving the location. This type of layout is used in the following conditions;

- When it is not practicable to shift the equipment
- When the operation requires only hand tools and simple equipment When only a
- few pieces are required to be produced; and
- When the production depends on the ability and responsibility of a set of workers belonging to the same trade.

This layout is employed in shipbuilding, heavy metal fabrication, aircraft manufacture and overhaul. In this layout, material movement is restricted to a minimum whereas the flow of tools and machinery is continuous and at a uniform rate, and is expensive and time consuming. This layout also ensures continuity of operation and requires that the responsibility be entrusted only to highly skilled labour. Again, the utilization of tools and machinery is low but changes in product design and scheduling can be made easily.

Process layout:

- In this layout, machines and services are grouped on a functional basis and operation of the same type are performed in the same area. For

  example, all welding work is carried out at one place and all turnings in another. This layout is used where:
- Expensive machinery is required
- Production involves a large variety of items having limited volume in each type
- Operations are not balanced in time, and
- When the demand is small and intermittent

This layout is used in small batch productions. This system affords higher utilization of machines and opportunities for specialisation. It also permits continuity and flexibility. On the other side, it has long flow lines having larger inventories of work in progress and is more difficult to plan and control. See Fig. 4.

Product layout:

In a product layout the machines are laid out in sequence of operations along the flow lines. This is also referred to as line layout. In this, the material flow is continuous at a uniform rate and operations are carried out as balanced by various machines. There is simultaneous work going on at each station. This layout is used when the volume of production is very high, the nature of work is standardized, process operations are balanced in time or when the continuity of materials can be maintained.

This layout is ideally suited for most of the plant and can be implemented after ensuring adequate supply of materials. It caters for smooth and logical flow lines and reduced material handling. However, it requires high skill from operators and makes the planning and control functions simple. Also, it does not offer flexibility in production design. Products layouts are of two types: (a) paced line (b) unpaced line.

Paced line layout: In a paced line layout, the work centres are connected through a conveyor belt which moves at fixed speed. The work centres are properly balanced so that the flow continues uninterrupted. Here the cycle time is decided by the speed of the conveyor.

Unpaced line: In this layout, the material handling equipment on the work centres is

independent of another. Each work centre processes units at its own rate. Here the cycle time is determined by the performance of the slowest machine. In either case, stoppage of one of the machines will close down the complete line. See Fig 5.

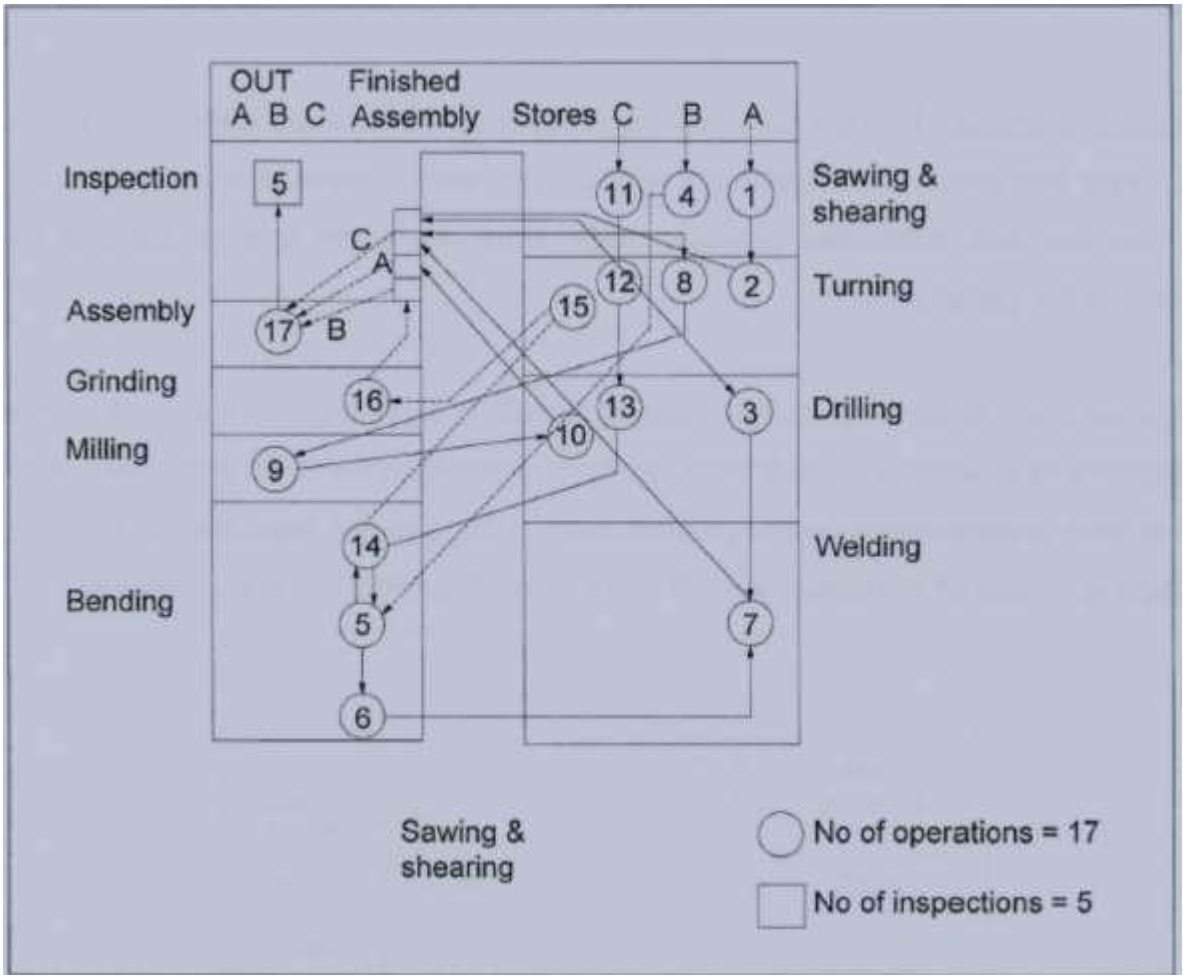

Fig. 4. A process layout

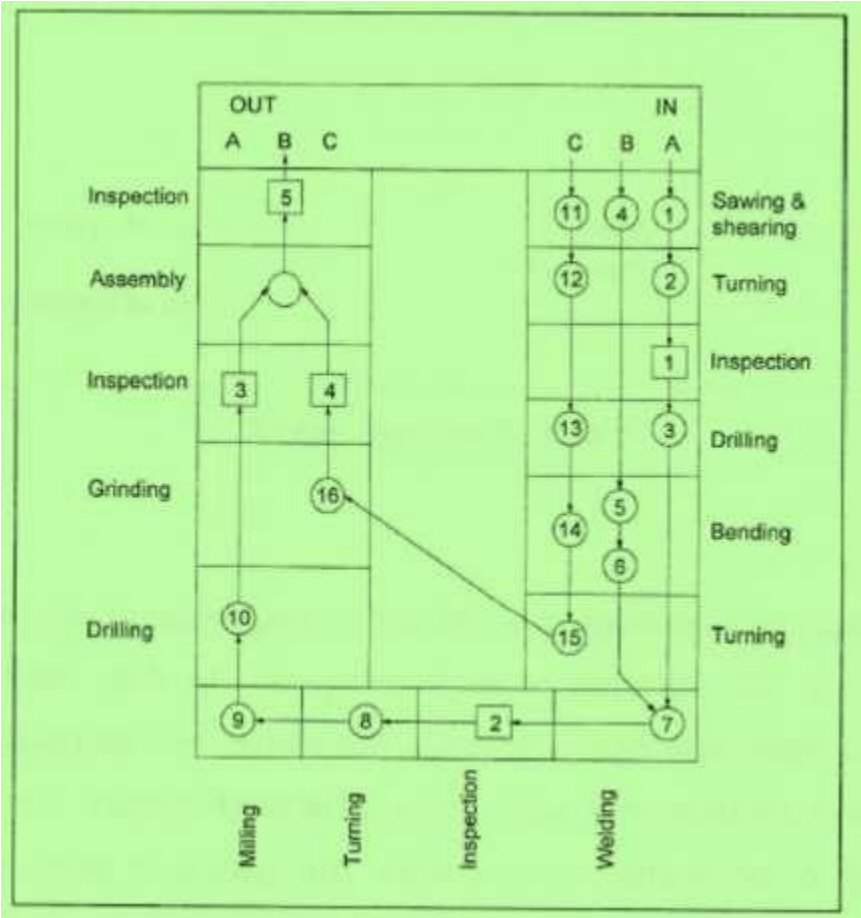

Fig. 5. A product layout

Combined Layout (Group Technology):

Generally, the best solution is the combination of the process and product layout for batch productions. Each process is set up as a unit and these units are arranged into a product layout (See Fig. 6).

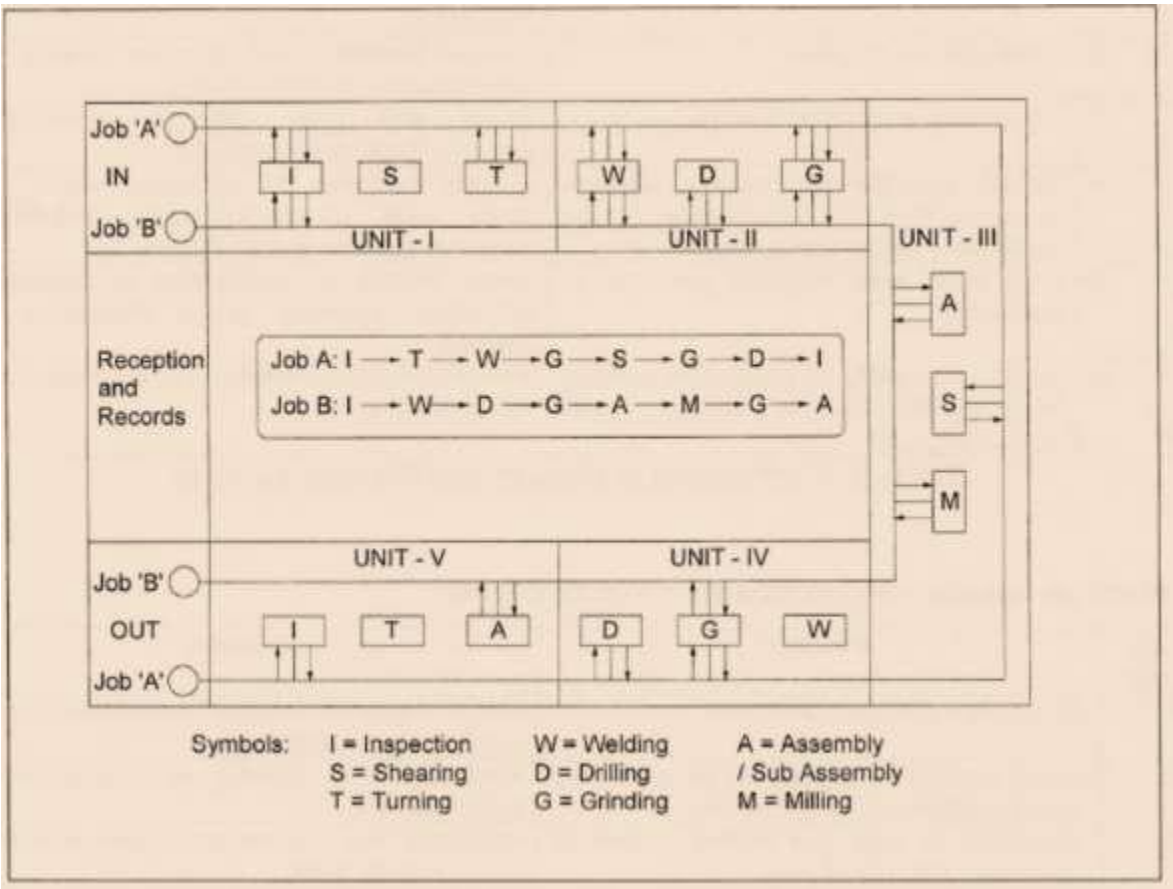

Fig. 6. Combined Layout (Group Technology)

Comparison between Product and Process Layouts

The comparison between process layout and product layout is given in Table 1 below.

Sl. No.	Product	Process
1	Lower total material handling cost	Less duplication of machine & less investment
2	Less work-in-progress	Greater flexibility of production (change of job sequence does not affect)
3	Lower total production volume	Better and more efficient supervision possible through specialisation
4	Greater incentive for groups of workers to raise level of performance (group incentive scheme successful	Greater incentive for individual worker to raise level of performance (individual incentive scheme is successful

5	Less floor area required per unit of production	Better control of complicated or precision processes specially where inspection is needed
6	Greater simplicity of production control, fewer control and record needed, lower accounting cost	Easier to handle breakdown of equipment by transferring work

Table 1. Comparison of Product and Process Layouts

Selection criteria — Product and Process Layout

Sl. No.	Product	Process
1	One or few standard products	Many types or styles of production or emphasis on special order
2	Large volume of production of each item over considerable eriod of time	Relatively low volume or production of individual item
3	Possibility of time and motion studies to determine the rate of work	Adequate time and motion studies difficult or impossible to make
4	Possibility of good labour and equipment balance	Difficult to achieve good labour and equipment balance
5	Minimum inspection required for sequence of operation	Many inspectors required during sequence of operation
6	Minimum number of very heavy equipment or equipment requiring very special facilities	Higher production capacity of very heavy equipment or equipment requiring very special treatment
7	Material and products require continuous handling by mechanical means	Material of products too large or too heavy to permit bulk or continuous handling by mechanical means
8	Little or no occasion to use same machines or work stations for more than one operation (minimum number of set-ups required	Frequent necessity to use same machine or work stations for two or more different operations

Table 2. Selection criteria Product, Process Layouts

Maintenance of Grain Processing Equipment

Modern food processing and production equipment are more advanced than before. This is in keeping with the evolving times. It means increased production capacity and yield, but it also means more complications when something breaks down or goes wrong. Establishing a proper maintenance strategy can help ensure that equipment keeps working effectively, mitigating the risk of a premature breakdown.

A well-maintained machine is a top-performing machine. With fresh lubricant, better calibration, and cleaner systems, your equipment will be able to keep the plant running smoothly. In addition to operating faster and with fewer interruptions, the quality and consistency of the food produced will also improve, such as more consistent cooking times and temperatures. 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. Adhering to a maintenance schedule helps keep better tabs on the performance of the facility, aiding in root cause analysis should something go wrong, and giving proof of maintenance in the event of a third-party audit. Just as changing the oil in the car regularly can save money on more costly repairs down the line, maintaining equipment on a fixed schedule can help make the most of the investments.

The first requirement is to take inventory of all equipment currently used in production and simultaneously asses the risk of each individual machine. Different types of equipment pose different hazards based on how they have been maintained. It is also required to prioritize the more important equipment including machines that have a higher potential impact on food safety and personnel operating them. It is prudent to set a schedule, optimize the timing and adhere to them strictly. Most of the manufacturers provide a guide on the maintenance of equipment and how to maintain it. Using this data, a master schedule is to be regularly looked into to keep track of all these important maintenance dates at once. The decision to shut down production for a day or work on maintenance on rotation has to taken based on the local implications of such an action.

Whatever approach is adopted for regular machinery maintenance, there should be proper documentation of these procedures. Preferably, a single location, accessible to all staff, that holds detailed description of how each machine should be serviced/ repaired should be available. This is important to establish that proper maintenance has been attended to and by whom. In addition, it should be transparent and simple enough for another person to take over should the situation warrant this. One person (or potentially more) who are responsible directly

for overseeing the maintenance programs should be identified. This fixes the responsibility to the maintenance protocol otherwise the staff may forget or skip the maintenance procedure to get things done faster in the short term.

All necessary items and equipment/ gadgets should be kept ready and on – hand. Different machines require specific items and tools. These tools/ gadgets also have to be maintained/ calibrated periodically and regularly. Some machines may need special types of lubricants or spare parts that can be purchased from the OEM. It is a good idea to keep at least some of these supplies in stock, especially if they are hard to find. A trade off between the cost and space requirement should be looked into and prioritized.

Sometimes, temporary fixes for the problems should also be planned for. Regular maintenance will not prevent everything from going wrong. A detailed maintenance record must and should be in place. If the facility is inspected for safety standards, these records are needed as evidence. Traceability is always a priority in the food industry.

There are many types of maintenance procedures being followed in the industry and grain processing equipment are no exception.

They are:

1. Preventive maintenance
2. Condition – based maintenance
3. Predictive maintenance
4. Corrective maintenance
5. Predetermined maintenance

These are explained in a little more detail below.

Preventive Maintenance

Preventive maintenance is aimed at catching and fixing problems before they happen. It is most commonly carried out in the form of regular inspections, usually occurring multiple times per year.

When you inspect a system or a piece of technology, carefully check for all signs of wear, tear or imminent breakdown. Replace damaged parts immediately. This will prevent having to go into “crisis mode” if something breaks unexpectedly.

The primary benefit of preventive maintenance is that it can eliminate unplanned shutdown time as you will ideally catch problems before they occur.

Condition-Based Maintenance

Condition-based maintenance is sometimes considered to be a more advanced alternative to preventive maintenance. Rather than being inspected according to a schedule, machines and systems are carefully observed for changes that could indicate upcoming failure.

With condition-based maintenance, technicians observe the system running and identify variables that could affect functioning, like temperature, vibration speed, power, the presence or absence of moisture, and more.

Another strategy within condition-based maintenance is predictive maintenance.

Predictive Maintenance

Predictive maintenance refers to a specific type of condition-based maintenance in which systems are constantly observed via sensor devices. These devices are attached to components of the system and feed constant, real-time data to software. The software then interprets this data and warns maintenance technicians of approaching danger.

Predictive maintenance is generally considered to be the most advanced and intensive type of maintenance. This is because there is a lot of data to interpret and the sensor devices themselves need to be regularly maintained and checked.

Corrective Maintenance

Corrective maintenance is initiated when a problem is discovered while working on another work order. With corrective maintenance issues are caught ‘just in time'.

For example, during a scheduled maintenance check or while fixing another issue, a maintenance technician notices that a pipe in a HVAC system is not working as it should. Corrective maintenance is then scheduled for a future date where the problem is repaired or replaced. Because corrective maintenance issues are found ‘just in time’, it reduces emergency repairs and increases employee safety.

Predetermined Maintenance

Unlike other styles, predetermined maintenance is carried out using rules and suggestions created by the original manufacturer, rather than the maintenance team. These suggestions are based on experiments and gathered data. The manufacturer provides statistics and guidelines, usually when the equipment is first purchased and will include data providing the average lifespan of both the entire system and its various parts. The manufacturer will suggest how often parts should be inspected, serviced and replaced.

Relying solely on a predetermined schedule may risk system failures as technicians may not be able to anticipate problems. It can also cause multi- family maintenance teams to replace parts too early, resulting in additional costs. Additionally, predetermined maintenance doesn't guarantee that a system won't break down since the program is based on statistics and not the actual state of the equipment.

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Chapter - 9
Food safety regulations & certification

Role of Food Testing Laboratories for Assuring Food Safety in India

Food Safety issues have been in the forefront of national and global consciousness, as significant size of our population is affected due to unsafe foods. Burden of unsafe foods not only strains health care system but also affects economic productivity of nation. Recent urbanization, fast changing life-style associated eating habits (more and more people are eating outside their homes, including vulnerable street foods) and industrial pollutants contribute to the hazards, which have frequently shown to cause adverse effects on human health. The pollution in atmosphere, soil and water brings its own share of contaminants to agricultural commodities. Synthetic substances, specially, pesticide / anti-biotic residues and indiscriminate usage of additives used in growing and processing of foods have frequently shown to cause adverse effects on human health.Most of the instances of food safety hazards result from microbiological contamination and specifically stability of dairy, animal products and fruits / vegetable products need to be ensured. Water is most common vector in food borne illness. Poor quality raw materials, inadequate processing, unhygienic and unsanitary handling practices and improper packaging and storage are the major causes for food safety hazards.Further toxicological effects of interactions between food and packaging materials and also the effect of such interactions on shelf-life and sensory quality of foods are extremely complex, which may pose threat to the safety of the foods.Every year, high proportion of population around the globe fall sick as result of unsafe foods. Incidences of Bovine Spongiform Encephalopathy (BSE), Salmonellosis, Shigellosis, Listeriosis, classical swine fever, Foot and Mouth disease, Avian Influenza and scares of dioxin, sudan red and melamine are not uncommon. Occurrence of serious outbreaks of food–borne diseases has demonstrated both their public health implications and social significance. Maintaining food safety and quality is essential in the entire chain of food production ranging from 1) primary food production at farmer‘s level; 2) primary food processing at the farm, dairy, abattoir and grain mills; 3) secondary / finish food processing like drying, baking, canning, freezing, brewing etc; 4) food distribution, both at Domestic and Import / Export levels; 5) food retailing and catering and 6) domestic food preparation.

The boom in food service establishments has not matched with effective food safety control and awareness. Food safety not often gets the focus, it deserves from manufacturers, retailers and food service providers – until there is a problem. Depending on scale of economy, processors need to establish their Quality Assurance programs, including HACCP, GHP, GMP to ensure the quality and safety of food and regulatory compliance. Looking ahead, risk assessments of novel dietary food supplements and nutraceuticals shall be the prime driver for food safety. It is also necessary that imported diverse foods are effectively regulated for their safety. Maintaining food safety is essential in the entire food chain; farm to fork.

Food Safety- Global Trends: Food Safety and quality are increasingly under the scrutiny of regulators and consumers. In addition to the fundamental basis of foods to be natural, the modern

concept of food safety embodies that the food be free or with minimum of contaminants (heavy metals, pesticide/anti-biotic residues, micotoxins, microbial and packaging material migrants). Different foods Standards have specifications towards purity of substances and presence of other contaminants. The FAO/ WHO Codex Alimentarius Commission (CAC) or Food Code, established in 1963, is responsible for laying down food standards / specifications, which would facilitate international trade ensuring fair practices in food business, besides protecting the health of consumers. The Codex Alimentarius comprises over 300 standards and guidelines relating to food quality, composition and safety.Additionally CAC lays Codes of Hygienic Practices, evaluates pesticide residues, contaminants as well as food additives towards their risk assessment and establishing their safe limits. United Nations General Assembly in 1985 have evolved Guidelines for Consumer Protection, which states "When formulating national policies and plans with regards to food, Governments shall take into account the needs of all consumer's food security and as for as possible, adopt the standards from Codex Alimentarius". In 1992, FAO / WHO recognized that access to nutritionally adequate and safe food is the right of each individual. In 1995, the agreement on Sanitary and Phytosanitary (SPS) Measures and the Agreement on Technical Barriers to Trade (TBT) formally recognized International Standards including Codex Alimentarius as reference point for facilitating International trade.Agreement on SPS sets out basic rules for food safety and standards for plant and animal health. All countries are required to maintain measures that food is safe for consumers and to prevent the spread of diseases among animals and plants. These SPS measures may include inspection of products, their specific treatments, permitted use of specific additives and setting of allowable maximum level of contaminants including pesticide residues. Basic aim of SPS agreement is to maintain the sovereign right of any government to provide the level of health protection, it deems appropriate, but to ensure that these sovereign rights are not misused for protectionist purposes and do not result in unnecessary barriers to International trade.

Food Safety-Indian Perspective: With the objective to establish single reference integrated law for foods and to overcome the implementation complexities of multiple acts regime, Government of India has enacted Food Safety and Standards Act (FSSA). Under FSSA 2006, Food Safety and Standards Authority of India (FSSAI), an autonomous statutory body with Ministry of Health and Family Welfare, GOI is established to formulate and implement the act. With effect from 5th August 2011, Food Safety and Standards (Food Products Standards and Food Additives) Regulation, 2011 has been implemented. The objective of FSSA is to lay down science based standards of foods and to regulate manufacture, sale and import to ensure safe and wholesome foods. The act lays emphasis on risk assessment, risk management and risk communication including those pertaining to use of food additives, processing aids or hazards to achieve Appropriate Level of Protection (ALOP) to Human Health. FSSA emphasizes labeling, traceability and recall procedures. FSSA incorporates Food Safety Management System, consisting of GMP, GHP and/or HACCP. An integrated approach on food safety and quality, supported with state-of-art analytics facilitates improved consumer protection and promotes domestic and international food trade. Instead of knee-jerk reaction, preventive approach is the core for food safety strategies.

Newer technological innovations, coupled with free-trade have necessitated the Food Regulation to be on a dynamic track. We need to have constant reminder againstnever being complacent and taking food safety for granted. Food safety management is a continuum process and it is never 'Done'. Achieving effective food safety in food supply chain would require inter-governmental harmonization of food safety regulation and its continued implementation, throughout the food chain with integration of public and animal health along with agricultural sustainability. Awareness, involvement and shared responsibility of all the stakeholders; including policymakers, scientific community, food business operators, quality assurance laboratories and consumer groups would be vital in ensuring the sustainability of quality and safety in food chain, wherein self-regulation shall be the ultimate goal.

Role of Food Testing Laboratories in Food Safety: Changing food trends bring increased attention to safety concerns in the handling, processing and packaging of foods. Increasing international trade has expanded food safety into a global business. Such movements will continue to drive the market for high-standard lab testing network for both domestic and export trade parameters including pesticide residues, antibiotic residues, heavy metals, mycotoxins, pathogens, and other contaminants. Therefore, robust network of food analytical laboratories is a critical and integral part of the supply of safe and quality food. It is the preventive safety-net 'expert system', which ensures that the customer gets the safe and quality food. As today's food supply is complex, capacity building of laboratories is the priority to effectively meet the analytical challenges. Laboratories require capacity building& regulatory support in adopting automation based surveillance. Use of probe based sensors along with active packaging is gaining wide acceptance globally in food safety surveillance. Validation of such processes call for greater attention.

Analytical food laboratories realize today the necessity of creating and implementing a quality system appropriate to the type, range and volume of work performed. The primary aim of the qualitysystem should be to ensure that analytical results leaving the laboratory are fit for their intended purpose, i.e. they are of appropriate quality especially as regards their trueness and precision.Food testing laboratories, deploying a comprehensive range of state-of- the-art analytical techniques are a necessary and vital arm of a responsible and responsive food regulatory system, important for robust implementation and enforcement These laboratories with adequate infrastructure, equipment, supplies, reference materials, access to calibration and maintenance, and quality assurance programme, are benchmarks that support the increasingly stringent quality and safety standards. An adequate number of food analysts with suitable qualifications, training, and experience form the core of a testing laboratory. Formal accreditation to ISO 17025-2017 standard, operation of effective internal quality control procedures together with participation in laboratory proficiency testing (PT) schemes are key elements in ensuring the quality of results generated by analytical laboratories. Food testing laboratories that meet recognized best practices of analytical competency are necessary arms of FSSA(I), the regulatory agency to more expeditiously utilize laboratory data to ensure food safety and health of population.

ISO / IEC 17025: 2017 standard has been developed with the objective of promoting confidence in the operation of laboratories. Requirements of Standard enable laboratories to demonstrate that they operate competently and are able to generate valid results. In general, compliance with a core quality standard requires that: 1. Laboratories must create and implement a suitable quality system and must document their quality policies and procedures in compliance with standard. 2. Laboratories must use methods of analysis which have been validated, whenever these are available. 3. Laboratories must create and implement suitable internal quality control measures, and must demonstrate competence by participating in suitable inter-lab comparison and proficiency testing schemes.

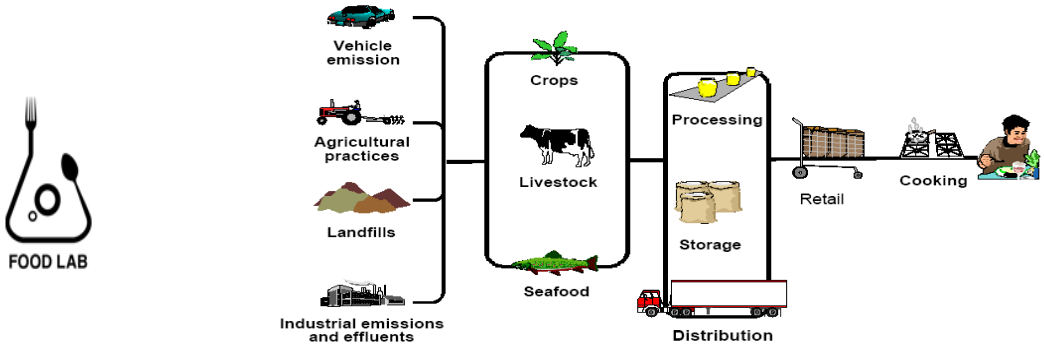
Laboratory quality control procedure for monitoring the validity of the test shall be appropriate to the relevancy of the method (Clause 7.7 of ISO 17025-2017 standard). The quality control procedure shall be planned, documented and include, but not limited to, the following: Use of certified reference materials traceable to nationally or internationally recognized body or provider accredited to ISO Guide 34. Where practicable, participate in proficiency testing programs or inter-laboratory comparison program. Targeted analytes should be spiked in representative batch of samples and recoveries recorded. Quality control data are recorded in such a way to detect trends and where applicable, statistical techniques are applied to review the results. Trend monitoring shall be planned, documented and where practicable control charts are applied to detect trend and manage quality control data within the pre-defined criteria. Before first accreditation, the laboratory must have participated successfully in at least one proficiency test. If no proficiency scheme is available, comparative testing with other accredited laboratories must be performed. Successful participation is defined as following: No false positive or false negative result must be reported. The reported result must have a z-score between -2 and +2. For spike recovery, the acceptable reported result must be between 70% and 120% of the spiked value.

National Accreditation Board for Testing and Calibration Laboratories (NABL) under Quality Council of India (QCI), responsible for accreditation of laboratories to ISO/IEC 17025-2017 standard has categorized different Food & Agricultural products under following groups: Bakery & confectionery products, Beverages (Alcoholic / Non-alcoholic), Canned & processed foods, Cereals, pulses & cereal products, Coconut and coconut products/Natural Plant Derivatives/Products, Coffee & cocoa products, Ediblecolors&flavors, Edible oils & fats, Food additives & preservatives, Fruit & fruit products, Herbs, spices & condiments, Honey & honey products, Infant food, Jams, juices, sauces & concentrates, Meat & meat products, Milk & dairy products, Natural waxes Nuts & nut products, Oil seeds & by-products, Poultry & poultry products, Starch & starch products, Sugar & sugar products, Tea, Vegetables & vegetable products and Nutraceuticals & Functional Foods, Fortified Food, Prebiotics, Probiotics, Nutritional Supplements, Residues in Food Products- Antibiotics, Chlorinated dioxins & dibenzofurans, Halogenated hydrocarbons,Mycotoxins, Pesticides, Phenols, Poly Chlorinated Biphenyl, Polycyclic aromatic hydrocarbons,Polyhalogenated biphenyls, Trace metal elements, Residues in Water- Antibiotics, Chlorinated dioxins & dibenzofurans, Halogenated hydrocarbons,

Mycotoxins, Pesticides, Phenols, Poly Chlorinated Biphenyl, Polycyclic aromatic hydrocarbons,Polyhalogenated biphenyls, Trace metal elements.

Along with other documents, NABL has also provided following guiding documents towards implementation of Laboratory Management System in accordance with ISO 17025-2017 standard:

- NABL 120- Classification of product groups for Testing laboratories
- NABL 142- Guidance on Measurement Traceability
- NABL 151- Application form accreditation of testing laboratories
- NABL 160- Guidance for documentation of Quality Manual
- NABL 161- Guidance document for Internal audit and Management review
- NABL 163: Guidance for PT participation



FOOD SAFETY STANDARDS, PACKAGING & LABELLING REGULATION IN INDIA

Every country needs an effective National Food Control System to protect health of the domestic consumers and to ensure the entry of safe and quality food products to the national international market. The challenges for food regulating authorities include increasing burden of food borne illness, food hazards, rapidly changing technologies in food production and processes, developing scientific food control systems, international food trade and need for harmonization of standards and growing consumer awareness. Specific concerns of food hazards include microbiological hazards, pesticide residues, misuse of food additives, toxic metals, toxins, adulteration, etc.

The laws regulating the safety and quality of food in India started as early as 1899, but were different in the different states and provinces. The variations in food standards created conflicts in inter-state trade within India itself. In 1954, the Government of India enacted the Prevention of Food Adulteration Act and its rules in 1955 to implement a uniform Food Regulatory System for the entire country. Later several Acts and Orders were implemented to complement and supplement each other to achieve total food safety and quality, covering all other categories of food products. The Food Safety and Standards Act 2006 was enacted in the year 2011 to overcome these shortcomings and providing impetus to safety standards at par with international

trade. This Act consolidates all the laws relating to food and establishes FSSAI as an Authority to lay down science-based standards for articles of food. This Act gives focuses on self regulation through better licensing and registration guidelines to process and sell safer food product to consumers. It introduced the graded penalty system for various offenses for selling unsafe, substandard and misbranded foods.

Since India is a signatory to World Trade Organization (WTO) agreements, to meet Sanitary and Phytosanitary Measures (SPS), Technical Barriers to Trade (TBT) and other issues the food standards especially with reference to Additives, Contaminants, Labelling, Food Recall System, Traceability, etc are being harmonised with the Codex Alimentarius Commission's guidelines keeping in mind the country's agricultural practices without compromising on the safety and quality of the foods.

FSSAI Administrative set up at State Level:

The enforcement of the Act at the State is via the State Commissioner of Food Safety, Designated Officers, Food Analysts, Food Safety Officers and Panchayati Raj / Municipal bodies. State regulatory body consists of Food Analysts, Chief Food Analyst and Joint Director at District, Zone and State level offices. These officers act as co-ordinators between Enforcement Officers and the Laboratory. Other activities related to food safety management viz: food surveillance, food recall, incident reporting, food terrorism and rapid alert system are directed by Food Safety Commissioner.

The Food Safety and Standards Act, 2006 has 12 chapters containing 101 sections and two schedules. It is supported by Food Safety & Standard Rules 2011 and its Regulations such as Food safety and standards (contaminants, toxins and residues) regulation, 2011, Food safety and standards (Food product standards and Food Additives) regulation, 2011, Food Safety and Standards (Laboratory and sampling analysis) regulation, 2011, Food safety and Standards (Licensing and Registration of Food businesses) regulation, 2011, Food Safety and standards (Packaging and Labelling) regulation, 2011 and Food safety and standards (Prohibition and Restriction on sales) regulation, 2011.

Some of the salient features of the Act are:

- Movement from multi-level and multi-department control to a single line of command
- FSSAI as a single reference point for all matters relating to Food Safety and Standards, Regulations and Enforcement
- Integrated response to strategic issues like Novel foods, Health Foods, Nutraceuticals, GM foods, international trade etc.
- Decentralization of licensing for manufacture of food products
- Achieve high degree of consumer confidence in quality & safety of food
- Effective, transparent and accountable regulatory framework within which the

industry can work efficiently

- Investor-friendly regulatory mechanism with emphasis on self regulations and capacity building
- Emphasis on a gradual shift from a regulatory regime to self compliance
- Consistency between domestic and international food policy measures without reducing safeguards to public health and consumer protection
- Adequate information dissemination on food to enable consumer to make informed choices.
- Compounding and Adjudication of cases – to reduce Court's workload and expedite the disposal of cases
- Graded penalty depending upon the gravity of offences
- Adequate representation of government, industry organizations, consumers, farmers, technical experts, retailers etc.
- Enforcement of the legislation by the State Governments/ UTs through the state Commissioner for Food Safety, his officers and Panchayati Raj/Municipal bodies

The Act, inter alia, incorporates the salient provisions of the Prevention of Food Adulteration Act, 1954 and is based on international legislations and instrumentalities. In a nutshell, the Act takes care of international practices and envisages a overreaching policy framework and provision of single window to guide and regulate persons engaged in manufacture, marketing, processing, handling, transportation, import and sale of food. The Act is contemporary, comprehensive and intends to ensure better consumer safety through Food Safety Management Systems and setting standards based on science and transparency as also to meet the dynamic requirements of Indian Food Trade and Industry and International trade.

New Provisions in the Act

- Covers Health Foods, supplements, nutraceuticals
- Issuing Licenses within a time frame of 2 months
- One composite license for unit(s) falling under one area
- No License for small food business operators; only registration is mandatory
- Central licensing from Authority.
- Provision of Improvement Notice by Designated Officers
- Training and Awareness programmes for Food Business Operators as well as Regulators;
- Encouraging self regulation through introduction of Food Recall Procedures
- Prosecution, if to be launched, should be within 1 year time frame
- Special Courts for summary trials
- Penalty of up to Rs 10 lakhs for distribution or sale of unhygienic and adulterated food.
- A punishment of a minimum of six months or life imprisonment for selling unsafe food.
- Compensation to Victims (for any case of Injury/ Grievous injury/ Death)

- Reward to informer (informing about the violators – adulteration etc.) by State Govt.

Salient features of Licensing & Registration Regulation under FSS Act are:

- Everyone in the food sector is required to get a license or a registration that would be issued by local authorities.
- Temporary stall holders are exempted from the license but need to get their businesses registered with the local municipality or Panchayat.
- Uniform Numbering System(UNS)(14 Digit Number)
- UNS helps in food recall in case of non-conformity
- Inspection components are
    - Location and surroundings
    - Layout and design of food establishment premises
    - Equipment
    - Facilities : Water supply, Cleaning , Drainage and waste disposal
    - Food operations and controls : Procurement, Storage, Processing, Packaging and Distribution
    - Management and supervision
    - Food testing facilities
    - Audit, documentation and records
    - Sanitation and maintenance of establishment premises: Cleaning and maintenance, Pest Control Systems
    - Personal hygiene
    - Product information and consumer awareness
    - Training

Some of the important terms defined under the FSS Act are:

Food:

Any substance, whether processed, partially processed or unprocessed, which is intended for human consumption and includes primary food i.e. all raw produce except those in hands of the grower, farmer, fisherman etc., genetically modified or engineered food or food containing such ingredients, infant food, packaged drinking water, alcoholic drink, chewing gum, and any substance, including water used into the food during its manufacture, preparation or treatment but does not include any animal feed, live animals unless they are prepared or processed for placing on the market for human consumption, plants prior to harvesting, drugs and medical products, cosmetics, narcotic or psychotropic substances: Provided that the Central Government may declare, by notification in the Official Gazette,

any other article as food for the purposes of this Act having regards to its use, nature, substance or quality.

Adulterant:
Any material, which is or could be employed for making the food unsafe or sub-standard or misbranded or containing extraneous matter.

Unsafe food:
An article of food whose nature, substance or quality is so affected as to render it
Injurious to health:

i. composed, whether wholly or in part, of poisonous or deleterious substance;
ii. Consisting, wholly or in part, of any filthy, putrid, rotten, decomposed or diseased animal substance or vegetable substance;
iii. Unhygienic processing or the presence in that article of any harmful substance;
iv. Substitution of any inferior or cheaper substance whether wholly or in part;
v. Addition of a substance directly or as an ingredient which is not permitted;
vi. Abstraction, wholly or in part, of any of its constituents;
vii. Being so coloured, flavoured or coated, powdered or polished, as to damage or conceal the article or to make it appear better or of greater value than it really is;
viii. Presence of any colouring matter or preservatives other than that specified in respect thereof;
ix. Food Article having been infected or infested with worms, weevils, or insects;
x. Food article being prepared, packed or kept under insanitary conditions;
xi. Food article being mis-branded or sub-standard or food containing extraneous matter;
xii. Containing pesticides and other contaminants in excess of quantities specified by regulations.

Substandard Food:
An article of food shall be deemed to be sub-standard if it does not meet the specified standards but does not render the food unsafe.

Misbranded:
Means an article of food with

i. False, misbranding or deceptive claims either on the label of the package, or through advertisement,
ii. If the article is sold as an imitation of, or is a substitute for, or is likely to deceive
iii. The package bears statement, design or device regarding the ingredients or the substances contained therein, which is false or misleading or
iv. Manufacturers name and address is false or
v. Contains any artificial flavouring, colouring or chemical preservative without declaration.
vi. Labelled not according to the Packaging and Labelling Regulation laid down under food act.

Proprietary Food:

Proprietary food means a food that has not been standardized under these regulations. In addition to the provisions including labelling requirements specified under these regulations, the proprietary foods shall also conform to the following requirements:

a) The name describing as clearly as possible, the nature or composition of food and/or category of the food under which it falls in these regulations shall be mentioned on the label

b) The proprietary food product shall comply with all other regulatory provisions specified in the Appendices of the Food Safety & Standards (Food product standards and Food Additives) Regulations.

Packing and Labeling Requirement as per FSSA 2006:

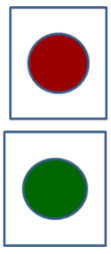
Food Safety & Standards (Packaging and Labeling) Regulation 2011, deal with Packing and Labeling of Foods under Food Safety and Standards Act 2006. Packaging materials used for packing food shall conform to Indian Standards(IS) derived by Bureau of Indian Standards(BIS) for various food packaging materials.

Mandatory labelling requirements:

Mandatory requirements for the food labelling are as follows:

- Every declaration on the package shall be Legible, prominent, definite, plain and unambiguous. It shall conspicuous as to size, number and colour
- Label shall not contain any false or misleading statement, claim, design, device, fancy name or abbreviation which is false or misleading. Unauthorized use of words showing imitation is prohibited.
- The language for the declaration on the label shall be English or Hindi in Devnagari Script; use of other language in addition to the above, is also permitted.
- It is mandatory that requires every package of food to carry a label with following particulars:
- The name, trade or description of food in the package.

- The names of ingredients used in the product in descending order of their composition by weight or volume.
- “Green” colour code shall be used for all vegetarian food products. If animal products including egg, other than milk and milk products, colour code of ‘Brown” for the non-vegetarian food shall be used on the label.
- It is also required to declare class name and INS number for the food additives used in the product.



- Nutritional information of the product shall be declared on the product label for all the food products other than those specified in the exception list.
- The name and complete address of the manufacturer and the manufacturing unit and in case the manufacturer is not the packer or bottler, the name and complete address of the unit is also to be declared on the label.
- Date of manufacture, Expiry date/ best before , Batch/Lot No, Net weight shall be declared on the label
- Any food article manufactured outside India is packed or bottled in India, the package containing such food article shall also bear on the label, the name of the country of origin of the food article and the name and address of the importer and premises of packing or bottling in India.

- FSSAI Logo with License number.
- Additional information such as trademark, trade name, UPC code (barcode) may also be given.

If the food is claimed to be enriched with nutrients such as minerals, proteins or vitamins, the quantities of such added nutrients shall be given on the label.

The rules also prescribe "form of labels" for various products such as infant milk substitutes, coffee-chicory mix, condensed milk, milk powder, blend of vegetable oils, mixed masala, malted milk food, iodized common salt, pan masala and supari, etc.

However, every food label shall also conform to Legal Metrology (Packaged Commodity) Rules 2011 under section 52 of the Legal Metrology Act 2009 (1 of 2010).

Nutritional Information requirements:

USA has comprehensive rules under Nutrition Labelling and Education Act, 1999 (NLEA) which requires nutrition labelling for most foods and authorizes the use of nutrient content claims appropriate FDA- approved health claims. Codex Alimentarius Commission has published guidelines on Nutrition labelling and guidelines for use of Nutrition claims.

Section 2.2.2.3 of the Food Safety & Standards (Packaging and Labeling) Regulation 2011 of FSSA 2006 has prescribed guidelines for Nutritional Information on the food label.
Mandatory pieces of information include Energy value, amount of Protein, Carbohydrates including sugar, Fat and any other nutrient for which nutrition claim has made. This includes claim on Cholesterol, SFA, MUFA, PUFA and Trans fatty acids. Some foods exempted from nutrition information includes raw agricultural commodities like wheat, rice, cereals, spices, spice mixes, herbs, condiments, table salt, sugar, jaggery and non–nutritive products like soluble tea, coffee, soluble coffee, coffee-chicory mixture, packaged drinking water, alcoholic beverages, processed

and pre-packed assorted fruits and vegetables and products that comprise of single ingredient, pickles, papads, foods served for immediate consumption in hospitals, hotels, food service vendors or halwais or foods shipped in bulk, as long as it is not for sale in that form to consumers.
If a claim is made about any of the optional components or if a food is fortified or enriched with any of them, nutrition information for these components becomes mandatory. The required nutrients may be selected to address today's health concerns. The order in which they must appear reflects the priority of current dietary recommendations.

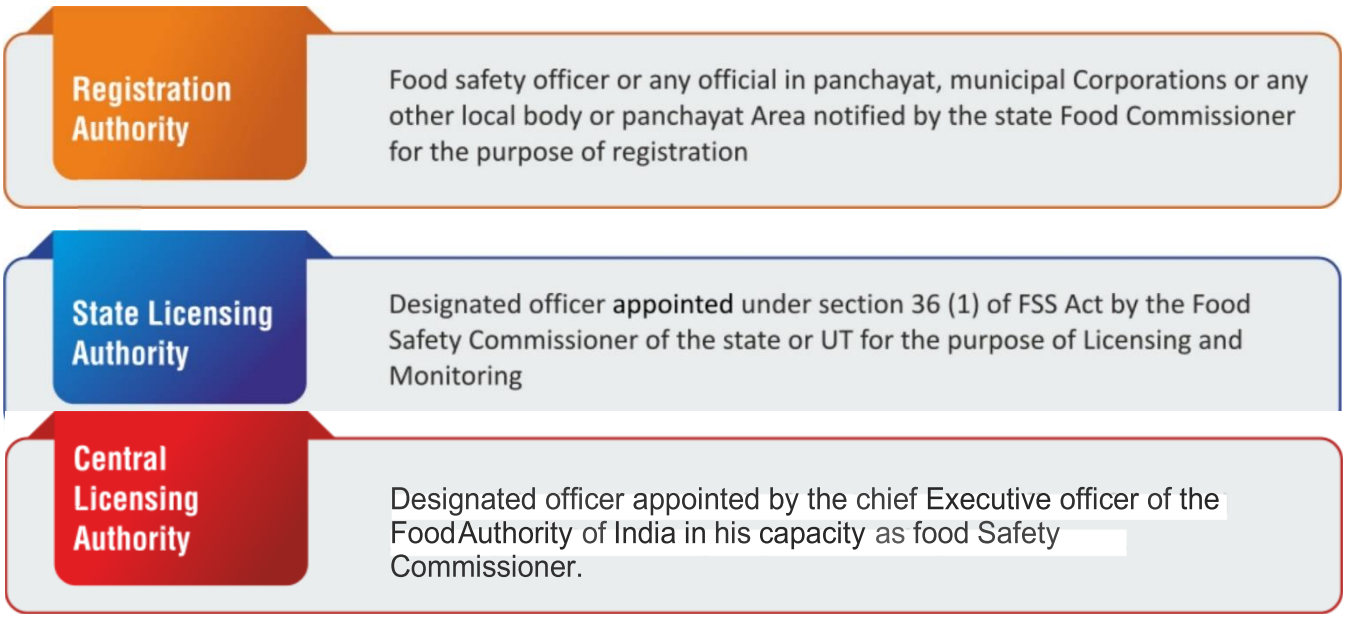
Conclusion:
A vast amount of work on food safety and quality has been undertaken in India. After more than 50 years of legislative development in India, for the first time uniform food safety standards based on science and risk assessment a par with international standards are being framed under the food act. The FSSAI will monitor and evaluate the effectiveness of these regulations on the safety of Indian food supply.

Licensing and Registration of Food Business under Food Safety & Standards Act 2006

A. As per Section 31 of Food Safety & Standards Act, 2006 and Regulation 2.1 of all Food Business Operators in thecountry have to be registered or licensed in accordance with the procedures laid down.

Salient Features:

1. No person shall commence or carry on any food business except under alicense.
2. In addition to the Designated Officer, Registering authority can also issue registration certificate.
3. Unified Licensing procedures for both centre and state and through the country- Single Window
4. Categorised into Central License, State License and Registration.
5. Introduction of exhaustive Safety, Sanitary and Hygienic conditions mandatory for registration/licensing.
6. Less inspections, more audit of system
7. Emphasis on Monitoring, Self-compliance and Surveillance.



Authorities responsible for Licensing & Registration of Food Business

Under the Food Safety and Standards Act, 2006, every Food Business Operator has to take License/Certificate to commence business. Food Licensing & Registration System (FLRS) has been developed under the guidelines laid down under Food Safety and Standards (Licensing & Registration of Food Businesses) Regulation, 2011.

FLRS is a web based system to facilitate Food Business Operators across the country to apply for License/Registration Certificate online and track their application status through the various stages of processing. FLRS is being used by FSSAI Regional and Sub-Regional Offices and State Governments to process applications online. It is hosted on a secure data centre at NIC and available 24X7to all stakeholders. FLRS allows FBOs to check their premises eligibility to the location or the activity being conducted on that premise. FLRS sends automatic alerts on email and sms to the FBOs at different intervals to facilitate faster processing of applications and allowing the FBOs to maintain continuity of their license/registration certificates.

The Designated Officers and FSOs are provided with user ID and password to access FLRS. Once Registration/License is applied on FLRS, the applications is pushed to the bin of DO. DO confirm the receipts of fee to FBO and scrutinises the documents uploaded with the Application. DO may send back application to the bin of FBO in FLRS in case of incompleteness or for clarification.

On the receipt ofa complete application including the additional information if asked for, the Licensing Authority shall issue an Application ID number to each applicant that will be referred to in all future correspondence between the Licensing Authority and the applicant.

After the issue of Application ID number the Licensing Authority may direct the Food Safety Officer or any other person or agency specially designated for such functions to inspect the premises in the manner prescribed by the Food Safety and Standard Authority of India in accordance with these Regulations. Such Inspecting Officer or person may issue a notice to the applicant, if it deems fit, guiding food business operator on necessary steps to be taken or changes or alteration to be made in the premises in order to ensure general sanitary and hygienic conditions as specified in Schedule 4. The applicant shall carry out the required steps, changes or alterations and intimate the Licensing Authority within 30 days or such period as may be allowed by the Licensing Authority.

Within a period of 30 days from receipt of an inspection report excluding the time taken by the applicant in complying with the advice, if any, given in the inspection report and verification thereof, the concerned Licensing Authority shall consider the application and may either grant license or reject the application. Provided that before refusing license an applicant shall be given an opportunity of being heard and the reasons for refusal shall be recorded in writing.

Live URL- http://foodIicensing.fssai.gov.in/

FAQs - https://foodIicensing.fssai.gov.in/PDF/FAQN.pdf

How to apply- https://foodIicensing.fssai.gov.in/how_to_appIy.html Help Desk—

Toll free Number 1800112100,

email— licensing@fssai.gov.in

B. Petty Food Business Operator

"Petty Food Operator" means any food business operator, who

(a) manufactures or sells any article of food himself or a petty retailer, hawker, itinerant vendor or temporary stall holder; or distributes foods including in any religious or social gathering except a caterer; or

(b) such other food businesses including small scale or cottage or such other industries relating to food business or tiny food businesses with an annual turnover not exceeding Rs 12 lakhs and/or whose

(c) production capacity of food (other than milk and milk products and meat and meat products) does not exceed100 kg/Itr per day or

(d) procurement or handling and collection of milk is up to 500litres of milk per day or

(f) slaughtering capacity is 2 large animals or 10 small animals or SO poultry birds per day or less

C. Process of Registration of Petty Food Business

1.Every petty Food Business Operator will register themselves with the Registering Authority by submitting an application for registration in Form A along with a fee of Rs. 100/-.

2.The petty food manufacturer has to 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.

3.The Registering Authority will 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.

4.In the event of an inspection being ordered, the registration will 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 aperiod of 30 days. If registration is not granted, or denied, or inspection not ordered within 7 days or no decision is communicated within 30 days 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. The registration cannot be refused without giving the applicant an opportunity of being heard and for reasons to be recorded in writing.

5.The Registering Authority will issue a registration certificate and a photo identity card, which has 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/manufactureof food in case of Petty Food Business.

6.The Registering Authority or any officer or agency specifically authorized for this purpose carries out food safety inspection of the registered establishments at least once in a year. Provided that a producer of milk who is a registered member of a dairy Cooperative Society registered under Cooperative Societies Act and supplies or sells the entire milk to the Society shall be exempted from this provision for registration.

D. List of documents required for a Registration Certificate

1. Photo of Food Business Operator

2. Document for Identity Proof like Ration Card, Voter ID Card, PAN Card, Driving License, Passport, Aadhar Card, Senior Citizen Card, Department Issued ID Supporting Documents (if any):- NOC by Municipality/Panchayat, Health NOC

E. Online System of Registration

Food Safety & Standards Authority of India has launched a online system for registration and licensing via Food Licensing & Registration System (FLRS), in order to facilitate the Food Business Operators to apply for registration or license and track their status from any corner of the world. This system sends alerts/ emails to the Food Business Operators for timely processing of the application and also to maintain continuity of the certificate.

F. Mode of payment:

All fees and charges payable is to be paid vide pay order, challan or demand draft or any online mode of payment as may be prescribed in this regard, by the concerned Food Safety Commissioner.

G. Validity and Renewal of Registration

Regulation 2.1.7 mentions the provisions for validity and renewal of a registration certificate issued to a food business operator.

(a) A Registration granted may be valid and subsisting, for a period of 1 to 5 years as chosen by the Food

Business Operator, from the date of issue of registration subject to remittance of fee applicable for the period and compliance with all conditions of registration. The renewal fee for one year is equivalent to one year registration fee.

(b) Any application for the renewal of a registration granted will be made in Form A not later than 30 days prior to the expiry date indicated in the license.

(c) The Registration will continue to be in force till such time that the orders are passed on the renewal application which in no case shall be beyond 30 days from the date of expiry of registration.

(d) Any Registration for which renewal has not been applied for within the period above shall expire and the Food Business Operator will have to stop all business activity at the premises. The Food Business Operator will have to apply for fresh Registration if he wants to restart the business.

H. Suspension or Cancellation of Registration Certificate

Section 32 of the Food safety & Standards Act, 2006 and the Regulations 2.1.8 of Licensing & Registration of Food Businesses, 2011 details the reasons and process to be followed by the Registering Authority in suspension or cancellation ofa registration certificate.

(a) The Registering Authority in accordance with the provisions of Section 32 of the Act may, after giving the concerned Food Business Operator a reasonable opportunity of being heard, suspend any registration in respect of all or any of the activities for which the registration has been granted under these Regulations afterrecording a brief statement of the reasons for such suspension, if there is reason to believe that the Food Business Operator has failed to comply with the conditions within the period mentioned in any Improvement Notice served under Section 32 of the Act. A copy of such statement shall be furnished to the concerned FoodBusiness Operator whose Registration has been suspended.

(b) The registering, may direct an inspection of the Food Business Operator's premise(s) within a reasonable period which shall not be less than 14 days from the date of order of suspension.

(c) In the event that the Registering is of the opinion, on a review of the inspection report, that the Food Business Operator has still failed to rectify the defects or omissions or comply with the conditions of the improvement notice causing the suspension, such authority may cancel the registration of the Food Business Operator aftergiving him an opportunity to show cause as provided under Section 32 (3) of the Act.

(d) Notwithstanding anything contained in these Regulations, the Registering Authority may suspend or cancel any registration or license forthwith in the interest of public health for reasons to be recorded in writing.

(e) A suspension or cancellation of registration shall not entitle the Food Business Operator for any compensation or refund of fee(s) paid in respect of the registration certificate or renewal thereof.

(f) After a period of 3 months from the date of cancellation above the Food Business Operator may make fresh application for Registration to the concerned authority if all observations made in the improvement notice have been complied with.

I. Modifications, Expansion or Changes in premise(s) after grant of Registration

(a) The Food Business Operators can take modifications, expansion or changes in the existing premise

after grant of a registration certificate, only after necessary approval from the Registering Authority. In such cases the Food

(b) Food Business Operators has to ensure that the Registering Authority always has up-to-date information on their food business establishments and will inform the relevant Authority of any modifications or additions or changes in product category, layout, expansion, closure, or any other material information based on which the certificate was granted and such information will be conveyed before the changes occur.

(c) Provided that any change that alters the information contained in the registration certificate will require an approval or endorsement in registration prior to start of business with such changes. The Food Business Operator will submit the original license to the Registering Authority along with a fee equivalent to one year license fee for effecting necessary changes. The Registering Authority may approve and issue an amended license incorporating such changes in activities within 30 days from the date of receipt of such information. While approving the afore mentioned changes the concerned Registering Authority takes into account the feasibility of carrying on the business and the legal and other relevant aspects of the desired modifications or additions or changes in activities and, if required, may order an inspection of the premises before granting the approval.

J. Transfer of Registration Certificate in case of Death

(a) In the event of death of the holder of a Registration certificate, such certificate will subsist for the benefit of the legal representative or any family memberofthe deceased or until the expiry of: —

(b) the period of 90 days from the date of death of the holder of a Registration certificate or license; or

(c) such longer period as the Designated Officer may allow, for reasons to be recorded in writing.

(d) The legal representative or family member of the deceased holder of the registration certificate will apply to the concerned Authority for transfer of such certificate in his favour.

(e) The registering Authority, may, after making such enquiry as it may deem fit, either approve the transfer of the Registration certificate if satisfied that the applicant is the legal representative, or refuse the request.

(f) The Registering Authority cannot not refuse the request without giving the applicant an opportunity of being heard and for reasons to be recorded in writing.

(g) Upon filing of application for transfer and pending the decision of the authority, the registration will continue to be in force.

K. Duplicate Registration Certificate

The Food Business may apply for a duplicate registration certificate to the Registering Authority in lieu of the original lost, destroyed, torn, defaced or mutilated. In this condition he has to pay a fee equivalent to one tenth of the fees payable for one year, which is equal to Rs. 10/- only.

L. Appeal

A Food Business Operator aggrieved by an order of the Registering Authority can prefer an appeal to the concerned Designated Officer or the Food Safety Commissioner, as per provisions laid down under Section 31(8) and 32 (4)of the Act.

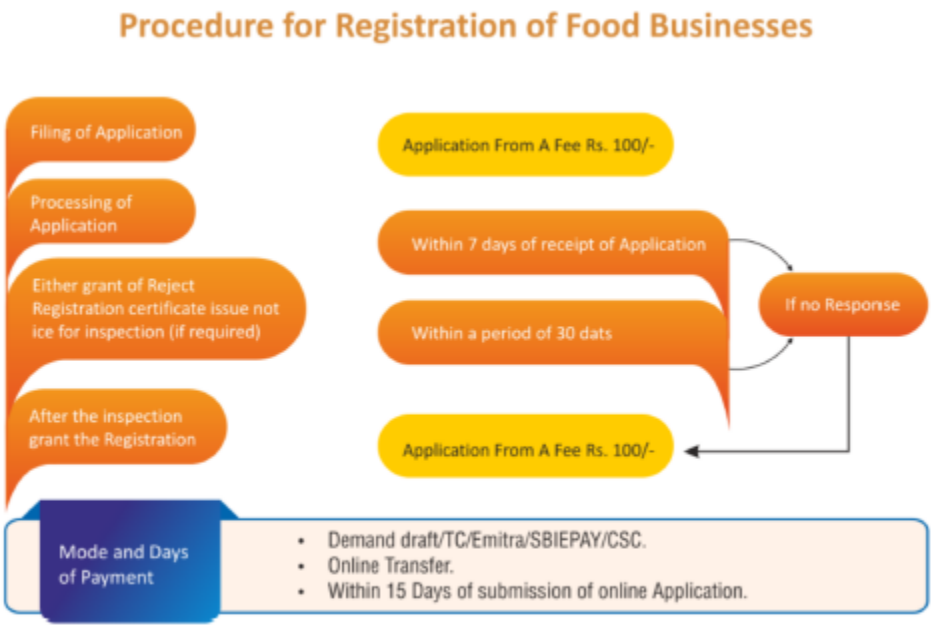
M. Food Business Operator to be bound by directions or order

(a) Every Food Business Operator to whom any direction or order is issued in pursuance of any provisions of this regulation is bound to comply with such directions or regulations and any failure on the part of the Food Business Operator to comply with such direction or order shall be deemed to be contravention of the provisions of these Regulations and will attract legal action under the provisions of the Act.

(b) Every manufacturer, distributor or dealer selling an article of food to a vendor shall give guarantee either separately or in the bill, cash memo, or label a warranty in Form E.

N. Food Business Operators under purview of Central Licensing & State Licensing

Food Safety Officers on the directions of the Designated Officers carry out inspections of both Food Business Operators under the purview of the Central Licensing Authorities and State Licensing Authorities. They also carry out enforcement activities in the area assigned to them, hence it is required that the Food Safety Officers shouldhave information regarding the food licensing.



SCHEDULE 1

A. List of food business falling under the purview of Central Licensing Authority

1.Dairy units including milk chilling units equipped to handle or process more than 50,000 litres of liquid milk/day or 2500 MT of milk solid per annum.

2.Vegetable oil processing units and units producing vegetable oil by the process of solvent extraction and refineries including oil expeller unit having installed capacity more than 2 MT per day.

3.All slaughter houses equipped to slaughter more than 50 large animals or 150 or more small animals including sheep and goats or 1000 or more poultry birds per day.

4.Meat processing units equipped to handle or process more than 500 kg of meat per day or 150 MT per annum.

5.All food processing units other than mentioned under (I) to (IV) including re-labellers and re-packers havinginstalled capacity more than 2 MT/day except grains, cereals and pulses milling units

6.100% Export Oriented Units.

7.All Importers importing food items including food ingredients and additives for commercial use.

8.All food business operators manufacture any article of food containing ingredients or substances or using technologies or processes or combination thereof whose safety has not been established through these regulations or which do not have a history of safe use or food containing ingredients which are being introduced for the first time into the country.

9.Food Business Operatoroperating in two or more states.

10. Food catering services in establishments and units under Central government Agencies like Railways, Air and airport, Seaport, Defence etc.

B. **List of food business falling under the purview of State Licensing Authority** - Apart from the list of Food Business Operators mentioned above in Schedule I, the rest Food Business Operators fall under the category of State License.

Further, in addition to the above an advisory was issued by the Food Authority dated 05 March, 2012 wherein eligibilitycriteria for Central Licensing, State Licensing and Registration was categorised.

C. Conditions of License

It is pertinent to mention the conditions of license in this manual as the Food Safety Officers should be aware of the conditions of license as he has a to play a active role in the inspection of licensed premise as per the directions of the designated Officer.

All Food Business Operators have to ensure that the following conditions are complied with at all times during the course of its food business. Food Business Operators have to:

1.Display a true copy of the license granted in Form C shall at all times at a prominent place in the premises.

2.Give necessary access to Licensing Authorities/ Inspecting Authorities/ Food Safety Officers of the

concerned area or their authorised personnel to the premises

3.Inform Authorities about any change or modifications in activities/content of license.

4.Employ at least one technical person to supervise the production process. The person supervising the production process shall possess at least a degree in Science with Chemistry/Bio Chemistry/Food and Nutrition/ Microbiology or a degree or diploma in food technology/ Dairy technology/ dairy microbiology/ dairy chemistry/ dairy engineering/ oil technology /veterinary science /hoteI management & catering technology or any degree or diploma in any other discipline related to the specific requirements of the business from a recognized university or institute or equivalent.

5.Furnish periodic annual return (1st April to 31st March), within upto 31st May of each year. For collection/ handling/ manufacturing of Milk and Milk Products half yearly returns also to be furnished as specified (1st April to 31st September before 30th November and 1st October to 31st March).

6.Ensure that no product other than the product indicated in the license/ registration is produced in the unit.

7.Maintain factory's sanitary and hygienic standards and worker's Flygiene as specified in the Schedule - 4 according to the category of food business.

8.Maintain daily records of production, raw materials utilization and sales separately.

9.Ensure that the source and standards of raw material used are of optimum quality.

10. Food Business Operator will not manufacture, store or expose for sale or permit the sale of any article of food in any premises not effectively separated to the satisfaction of the licensing authority from any privy, urinal, sullage, drain or place of storage of foul and waste matter.

11. Ensure Clean-In-Place systems (wherever necessary) for regular cleaning of the machine &equipments.

12. Ensure testing of relevant chemical and/or microbiological contaminants in food products in accordance with these regulations as frequently as required on the basis of historical data and risk assessment to ensure production and delivery of safe food through own or NABL accredited /FSSA notified labs at least once in six months.

13. Ensure that as much as possible the required temperature should be maintained throughout the supply chain from the place of procurement or sourcing till it reaches the end consumer including chilling, transportation, storage etc.

14. The manufacturer/importer/distributor will buy and sell food products only from, or to, licensed/registeredvendors and maintain record thereof.

D. Other conditions of License

1.Proprietors of hotels, restaurants and other food stalls who sell or expose for sale savouries, sweets or other articles of food shall put up a notice board containing separate lists of the articles which have been cooked inghee, edible oil, vanaspati and other fats for the information of the intending purchasers.

2.Food Business Operator selling cooked or prepared food has to display a notice board containing the nature of articles being exposed for sale.

3.Every manufacturer [including ghani operator] or wholesale dealer in butter, ghee, vanaspati, edible oils, Solvent extracted oil, de oiled meal, edible flour and any other fats have to maintain a register showing the quantity of manufactured, received or sold, nature of oil seed used and quantity of de-oiled meal and edible flour used etc. as applicable and the destination of each consignment of the substances sent out from his factory or p ace of business, and shall present such register for inspection whenever required to do so by the Licensing

4.The producer or manufacturer of vegetable oil, edible oil and their products is eligible for license under this Act, only when he has own laboratory facility for analytical testing of samples.

E. Issue of Duplicate License

1.Where a license is lost, destroyed, torn, defaced or mutilated, the applicant may apply for a duplicate copy of license during the validity period, accompanied with a fee amounting to 10% of the applicable License fee.

2.On receipt of such an application, the Licensing Authority grants a duplicate copy of the license, as the case maybe to the applicant with the word "Duplicate" appearing prominently thereon.

SCHEDULE - 2

Fees for License issued by Central Licensing AuthorityFees for License issued by State Licensing Authority		Rs 7500/-
1.	Manufacturer /MiIIer (a) Above 1MT per day Production or 10,001 to 50,000 LPD ofmilk or 501 to 2500 MT of milk solids per annum	Rs. 5000/-Rs.
	(b) Below 1 MT of Production or 501 to 10,000 LPD of or 2.5 MT to 500 MT of milk solids per annum milk	3000/-
2.	Hotels -3 Star and above	Rs. 5000/-
3.	All Food Service providers including restaurants/boarding houses, clubs etc. serving food, Canteens (Schools, Colleges, Office, Institutions), Caterers, Banquet halls with food catering arrangements, food vendors like dabba wallas etc.	Rs. 2000/-
4.	Any other Food Business Operator	Rs. 2000/-

The fees paid by any applicant for a license is not be refundable under any circumstances.

GMP & HACCP practices in Food Processing

Good manufacturing practice (GMP) plays a major role in maintaining the food safety. There are two primary motivations for implementing the GMP programmes. One motivation is a concern for the well-being of the consumer and the other is the desire to comply with the regulatory standards. Implementation of GMP and following good sanitation methods besides taking proper care of hygiene can keep the food products safe till it is consumed.

GMPs comprise procedures, processes, controls and precautions that ensure safe, wholesome food. GMP also facilitates the production of foods of uniform quality. Although this is an important consideration, maintenance of product safety remains the preeminent objective.

Fundamentals

The fundamentals of GMPs are simple. They comprise four practices –

(i) Exclusion of undesirable microorganisms and extraneous material.
(ii) Removal of undesirable microorganisms or extraneous material.
(iii) Inhibition of undesirable microorganisms
(iv) Killing of undesirable microorganisms.

The invisibility of microorganisms and most extraneous material poses a demanding challenge to the effective implementation of these simple practices.

The primary function of microorganisms in nature is self propagation. In the process of performing their primary role, many complex chemical reactions essential for their survival is also carried on. In general, varying number of bacteria, yeast and molds are common to occur on raw materials. Food is prone to microbial contaminants, which are known more for the undesirable changes which they bring about in foods. These microbial contaminants are of spoilage and/or pathogenic types. The spoilage activities of microorganisms manifest in the form of defects arising out of the action of microbial enzymes on food constituents giving rise to various off-flavours such as bitter, putrid, rancid and fruity. A more serious aspect of microbial contamination is the possibility of serious health hazards due to the presence of potential food poisoning microorganisms and their toxic metabolites leading to food poisoning outbreaks. In most of these poisonings, the food serves only as a vehicle of transmission.

Potential sources of microbial contaminants

- Soil
- Water
- Air
- Personnel
- Ingredients
- Product to product contact
- Packages
- Pests
- Food processing equipment

Microbial Hazard

Food borne illness is estimated to afflict 10% of the population annually. Infections are diseases caused by the presence of viable, usually multiplying microorganisms at the site of inflammation. In this case, the viable bacterial cells have been ingested with food. Bacterial food poisonings are of two types namely ***infection*** and ***intoxication.*** Infections are diseases caused by the presence of viable, usually multiplying microorganisms at the site of inflammation. In this case, the viable bacterial cells have been ingested with food. The dose required to produce as infection varies with the type of microorganism, even though the microorganism will usually multiply in the gastro-intestinal tract or some other organ of the body to produce the infectious disease. Common bacteria involved in foodborne infections are *Salmonella* spp., *Shigella dysenteriae, Campylobacter jejuni, Clostridium perfringens, Escherichia coli, Yersinia enterocolitica. Listeria monocytogenes* and *Vibrio parahaemolyticus.* Intoxications are strictly poisonings implying the ingestion of a toxin performed in the ingested food. Common bacteria involved are *Staphylococcus aureus, Bacillus cereus* and *Clostridium botulinum.* Bacterial sporeformers are of considerable importance in foods due to their unusual power of heat resistance. They are predominant in bringing about spoilage of foods. At the same time, these sporeformers are also known to cause severe health hazards.eg. ., *Bacillus* and *Clostridium* belonging to the family: Bacillaceae. Sporeformers are known to cause spoilage of almost all types of food with predominance in canned foods.

Mycotoxins are chemically diverse group of toxic secondary metabolites that are produced in agricultural commodities by Fungi. By general consent the name Mycotoxins is restricted to food borne and feed borne fungi. Most important field fungi that are capable of producing toxins are the *Fusarium, Alternaria, Claviceps, Helminthosporium* and *Cladosporium*. The important storage fungi are the *Aspergillus* and *Penicillium*. Aflatoxins are produced by *Aspergillus flavus, A. parasiticus* and *A. nomius*, which are ubiquitous in nature.

FACTORS AFFECTING MICROBIAL GROWTH

Intrinsic	**Extrinsic**
pH	Storage temp.
Moisture content	Relative humidity
Nutrients	Gases in environment
Antimicrobials	

Effect of physical & chemical agents depends on

- ✓ Type of microorganism exposed to the agent
- ✓ Stage in the microorganism's lifecycle
- ✓ Time of exposure
- ✓ Microbial load
- ✓ Nature and complexity of food

Spoilage by yeast and molds

They constitute a large and divergent group of microorganisms. They can adapt to a wide range of environmental conditions and are found on various commodities, or inadequately cleaned food processing equipment, and food storage facilities. Molds are to a less extent than yeast can initiate growth over a wide range from below pH 2 to above pH 9. They change the pH of substrate to pH 4 to 6.5. The temperature range of most yeast and molds are broad (5 to 35°C). The yeasts are larger than bacteria, their oval, elongated, ellipsoidal and elliptical cell shape, budding nature is unique. They produce variety of pigments. Film yeast, these grow on surface of acid products like sauerkraut and pickles (*Candida and Hansenula).* Top yeasts carry on conversion of sugars to alcohols at the top of the vessel, while the bottom yeast functions at the bottom of the vessel. Many food borne yeasts and molds like *Zygosaccharomyces, Eurotium* and *Xeromyces sp.* can grow at a water activity 0.85 or below. Most of the fungi are aerobes.Yeast and molds can form various degrees of food decomposition. The growth of yeast and molds can manifest as rot spots, pustules or scabs, slime white or variously coloured mycelia and spores.

Spoilage of food by bacteria

Mesophilic aerobes and anaerobes may comprise of rods, cocci, or vibrios; sporeforming or nonperforming; gram +ve or gram –ve forms. These bacteria may be hetero-, or homo-fermenters. They can be grouped as proteolytic, pectolytic, amylolytic or lipolytic forms. Bacteria in food microbiology can be grouped by their physiological characteristics. Microbes are also classified into three temperature groups- thermophiles, mesophiles and psychrophiles. The spoilage bacteria can grow at refrigerated temperature and some can withstand normal processing temperature.

Preventive measures

HACCP stands for ‘Hazard Analysis Critical Control Point’. HACCP is a system that prevents potential problems before they happen. HACCP has gained widespread international acceptance as an important tool for improving food safety management

7 principles of HACCP implementation

- Hazard analysis
- Determine the Critical Control Points (CCP)

- Establish critical limits
- Critical Control Point (CCP) monitoring
- Corrective actions
- Establish verification procedures
- Record keeping procedures

- ❖ Follow of hygiene rule codes to ensure Microbial Food Safety
- ❖ Follow of Good Manufacturing Practices

Conclusion

The responsibility to safeguard our food supply is shared by everyone involved, from the grower to the consumer. This includes growers, farm workers, packers, shippers, transporters, importers, wholesalers, retailers, government agencies, and consumers. While research is ongoing and will continue to provide new information and improved technologies, the industry is urged to take a proactive role to minimize those microbial hazards over which they have control. Operators are encouraged to utilize GMP and evaluate their own operations and assess site-specific hazards so they can develop and implement reasonable and cost effective agricultural and management practices to minimize microbial food safety hazards.

Nutritional Analysis of Foods and Use of instrumental techniques in food labs

Proximate analysis

a. Determination of moisture content

Moisture was determined by keeping the sample in oven at 100-110 ºC for 6 h and then cool to room temperature in desiccator. The loss in weight was treated as a measure of moisture content. (AOAC 20th EDN. 2016, 953.07)

b. Determination of ash content

For ash content, the samples were heated in muffle furnace at 550 ºC, until white or grayish white ash was obtained. Weight of the ash was calculated as ash. (AOAC 20th EDN. 2016, 923.07)

c. Determination of crude fiber content

For Crude fibre, the sample was treated with 1.25% H_2SO_4 and 1.25% NaOH filtered and washed with hot water after each step. The residue obtained was dried in oven at 100-110 ºC and ashed at 550 ºC in furnace. The loss in weight on ignition was expressed as content of crude fiber (AOAC 20th EDN. 2016, 962.09).

d. Determination of fat content

Total fat was extracted from the sample with petroleum ether (60-80 ºC) in a Soxhelt apparatus for about 16 h. The residual solvent was evaporated in a preweighed flask and increase in weight of flask gave total fat (AOAC 20th EDN. 2016, 999.36).

e. Determination of protein content

Nitrogen content in the sample was estimated by using Kjeldahl method and protein was calculated by multiplying the evaluated nitrogen by factor 6.25 (AOAC 20th EDN. 2016, 984.13).

f. Determination of carbohydrate by difference content

The value of total carbohydrate was given by: 100-(percentage of moisture + percentage of ash + percentage of total fat + percentage of protein + percentage of crude fiber) (Nutritive Value of Indian Foods, NIN-ICMR, Dr. C. Gopalan).

g. Determination of Calorific value content

The calorific value was calculated by: [(4 x carbohydrate by difference) + (4 x protein) + (9 x total fat)] and the result is expressing in kilocalories/ 100 g (Nutritive Value of Indian Foods, NIN-ICMR, Dr. C. Gopalan).

Mineral analysis

a. What is a minerals?

In the context of nutrition, a mineral is a chemical element required as an essential nutrient by organisms to perform functions necessary for life. Minerals originate in the earth and cannot be made by living organisms. Plants get minerals from soil.Most of the minerals in a human diet come from eating plants and animals or from drinking water. As a group, minerals are one of the four groups of essential nutrients, the others of which are vitamins, essential fatty acids and essential amino acids.

b. What is a mineral element?

A mineral is a naturally occurring inorganic element or compound having an orderly internal

structure and characteristic chemical composition, crystal form, and physical properties. Minerals may be metallic, like gold, or nonmetallic, such as talc.

c. What is the source of minerals?

Brazil nuts, cashew nuts, cheese, eggs, milk, chicken, liver, garlic, onion, green vegetables, mackerel, salmon, tuna, sunflower seeds, whole wheat bread.

d. What are the essential minerals?

There are 16 essential minerals: calcium, phosphorus, potassium, sulfur, sodium, chloride, magnesium, iron, zinc, copper, manganese, iodine,
selenium, molybdenum, chromium, and fluoride.

e. What foods are rich in minerals?

High mineral dark leafy greens include spinach, kale, swiss chard, and turnip greens.
Fish are a top source for essential minerals. These include Calcium, Potassium, Phosphorus, Magnesium and Selenium.
Fish are also a top source of protein, and heart healthy omega 3 fatty acids.

Essential chemical elements for humans:

At least twenty chemical elements are known to be required to support human biochemical processes by serving structural and functional roles as well as electrolytes.
Calcium: An adult female has 920-1000 g, while an adult male has ~1.22 kg, it contained in bones and teeth, and the other 1% in extracellular fluids, intracellular structures and cell membranes.
Phosphorus: It makes up about 1% of a person's body weight.
The last four major minerals (potassium, sodium, chlorine and magnesium) make up only about 0.85% of the weight of the body.
Most of the known and suggested mineral nutrients are of relatively low atomic weight, and are reasonably common on land, or, at least, common in the ocean (iodine, sodium).

Vitamins analysis

Vitamins:

- Are organic compounds.
- Are indispensable in very small amounts in the diet.
- They have specific and individual functions to promote growth or reproduction, or to maintain health.

- They regulate metabolic processes, control cellular functions and prevent diseases.
- Vitamins are unstable in foods.
- Processing and cooking conditions cause vitamin loss. The losses vary widely according to cooking method and type of food.
- Vitamin degradation depends on specific parameters during the culinary process, e.g., temperature, oxygen, light, moisture,pH, and obviously length of exposure.

Classification of Vitamins

- Based on solubility Vitamins are classified as either fat-soluble (lipid soluble) or water-soluble. Vitamins A, D, E and K are fat-soluble Vitamin C and B is water soluble.
- **FAT-SOLUBLE VITAMINS:** A, D, E and K
- **WATER-SOLUBLE VITAMINS:** B complex vitamins (B1- Thiamin, B2- Riboflavin, B3- Niacin, B6- Pyridoxine, Pyridoxal, Pyridoxamine, B9- Folic Acid, B12-Cobalamin), biotin and pantothenic acid.

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