College of Community and Applied Sciences
Maharana Pratap University of Agriculture and Technology

E- Text Compendium on

FOOD PRESERVATION AND STORAGE

FND-213

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Authors

FOOD PRESERVATION AND STORAGE

FND 213

SYLLABUS

UNIT 1

INDIAN AND GLOBAL SCENARIO ON FOOD PRODUCTION AND PROCESSING

Introduction

Indian agriculture is a way of life and it supports about 60 per cent of population for their livelihood and contributes 17% of GDP in India. Engineering inputs are vital for modernization of agriculture, agro-processing and rural living. It is needed for development and optimal utilization of natural resources, appropriate mechanism of unit operations of agriculture for increasing production, productivity with reduced unit cost of production for greater profitability, economic competitiveness and sustainability. Mechanism also imparts capacity to the farmers to carry out farm operation with dignity, with ease and freedom from drudgery, making the farming agreeable vocation for educated youth as well. It helps the farmers to achieve timeliness and precisely mater and apply costly input for better efficacy and efficiency, achieving higher productivity with reduced application of inputs.

Agricultural produce and by-products are perishable in nature in varying degree and their perishability gets exploited on the market floor compelling distress sales orchestrated by factors of demand and supply, intervention of the faces of marketing in the absence of matching post-harvest technology (PHT) and agro-processing infrastructure. Agricultural Engineering inputs are also needed to assure remunerative prices to the growers and a share in the value addition to the growers through on-farm PHT and value addition to their produce and by-products in order to strengthen their livelihood base landholdings are decreasing for their socio-economic sustenance and assure minimum standards of living.

India is the largest country in food production, processing, supply, and consumption at the global level. The food processing sector of India is poised for huge growth and contribution to increasing economic growth of the country. Food processing sector in India has emerged as a highly profitable sector due to value addition and emerging technologies. The food market of India has 6th rank with 70% of sales and 5th rank in production, consumption, and export in the world. India export 13% of the total manufacturing and 6% of the industrial investment. India contributes to Gross value added 8.80% and 8.39% through manufacturing and agriculture sector. The Government of India contributes to the development and growth of food processing sector with the help of the Ministry of Food Processing Industries (MOFPI). It is working on these aspects with the help of different schemes and subsidies. It also works on foreign collaborations for investments and 100% export oriented units in the food processing sector. The organic food market of India will increase three times by 2020 (expected). The foreign direct investment (FDI) received around US$ 7.54 billion by Indian food processing sector till April 2000 - March 2017. According to the report of Confederation of Indian Industry (CII) expected, the next 10 years food processing sector of India will receive foreign investment around US$ 33 billion and also generate the employment. The online seller companies like and global e-commerce giant are also planning to invest US$ 515 million in the food retailing sector by next five years.

FOOD, AGRICULTURE AND MECHANIZATION

Food is the first and the foremost requirement of the people for their survival. It provides nutrients like proteins, carbohydrates, fats minerals and vitamins. It involves cultivation of field crops, horticulture, animal raising and aquaculture. Agriculture is practiced in two phases.

i) the production agriculture and the goal is to get maximum productivity and

ii) post production agriculture where the major targets are prevention of loss and value addition. Agriculture is practiced for self and/or trade.

Food Processing

Food processing operations includes many methods that are used to add value to the raw food materials (including marine products, poultry and meat) which can be consumed by human beings or animals. Raw food materials are transformed into edible products processing and value addition. The operations involved in food processing are mainly classified into two groups, viz., primary processing and secondary processing. This provides employments to rural people including women and prevents capital drain from rural to urban areas and thereby helps in narrowing down the economic disparity between rural & urban population.

Primary processing relates to conversion of raw agricultural produce, milk, meat and fish into a commodity that is fit for human consumption. It involves steps such as cleaning, grading, sorting, packing, etc.

Secondary and tertiary processing industries usually deal with higher levels of processing where new or modified food products are manufactured.

Present status of Food Processing

To meet the current demand of food materials, the industrial food processing sector has emerged. The food processing sector in the country is mainly handled by the unorganized sectors. About, 42% of the output comes from the unorganized sector, 25% comes from the organized sector and the rest of it comes from the small scale players. The small-scale food processing sector is a major source of employment and adds value to crops by processing. It is a major source of food in the human diet.

The small-scale food processing sector is, however, under increasing threat and competition from the large manufacturers who, through economies of scale and better presentation and marketing. Good packaging lies at the very heart of presentation and thus customer appeal. It is an area of vital importance for small and medium food manufacturers if they are going to continue to compete and expand. With food processing, it is possible to maintain a nutritious and safe food supply for the millions of people that inhabit both urban and rural areas. Improvement in processing efficiency, by increased yield of usable product, is a tangible means of reducing food loss and increasing food supply. Demand for increased convenience of food preparation in the home, institution and restaurant has created a need from processing industries for food ingredients as well as new food forms.

Importance of Food Processing

All the raw food materials are processed to improve their palatability, nutritional value and shelf-life.

Foods are processed for five major reasons:

1) preservation for later consumption or sale to fetch better price
2) removal of inedible portions
3) destruction or removal of harmful substances
4) conversion to forms desired by the consumer and
5) subdivision into food ingredients.

Generally, the first - preservation for later consumption or sale – is the primary reason for food processing.

Field crops, including grains, oilseeds, sugar crops and forages are major contributors of the nutrients required by man either through direct consumption of the seed kernel or isolated components as food, or through utilization of the plant and byproducts as feed in the production of meat, poultry, milk, eggs and fish. Field crops also have major non-food uses. However, in essentially all instances, harvested field crops must be processed in some manner prior to utilization as food or feed or in industry so as to reduce their post harvest losses. A nation-wise study on quantitative assessment of harvest and post harvest losses for 46 agricultural produces in 106 randomly selected districts was carried out by Central Institute of Post Harvest Institute (CIPHET) and found the results as given in Table 1.

Table 1. Per cent of losses estimated for major produces

Cereals	Pulses	Oilseeds	Fruits & Vegetables	Milk	Fisheries	Meat	Poultry
3.9 – 6.0	4.3-6.1	6.0	5.8-18.0	0.8	2.9	2.3	3.7

Scope of Food Processing

India is the world's second largest producer of food next to China, and has the potential of being the biggest with the food and agricultural sector. The total food production in India is likely to double in the next ten years and there is an opportunity for large investments in food and food processing technologies, skills and equipment, especially in areas of Canning, Dairy and Food Processing, Packaging, Frozen Food/Refrigeration and Thermo-Processing. Fruits & Vegetables Processing, Fisheries, Milk & Milk Products, Meat & Poultry, Packaged/Convenience Foods, Alcoholic Beverages & Soft Drinks and Grain processing are important sub-sectors of the food processing industry. The consumer product groups like confectionery, chocolates and cocoa products, Soya-based products, mineral water, high protein foods, soft beverages, alcoholic and non-alcoholic fruit beverages, etc. along with the health food and health food supplements is another rapidly rising segment of this industry which is gaining vast popularity.

India produces nearly 16% of the world's total food grain production. It is one of the largest producers of agricultural produce. With a population expected to reach to about 590 million people by 2030 in urban India, India has a huge potential domestic demand for processed foods other than the demand from the exports. There are many socio-economic factors that are driving the demand side of the Indian Food Processing Industry. The changing consumption patterns, both in tier 1 and tier 2 cities, rising income levels among the middle-class and changing lifestyles, are some of the factors providing the demand side push for the Food Processing Industry. Moreover, the central government has given a priority status to all agro-processing businesses.

Key constraints for growth

Though there are many promising dynamics which support good growth of this industry, there are still some significant constraints which, if not addressed properly, can impede the growth prospects of the Food Processing Industry in India. One of the biggest constraints is that this industry is capital intensive. It creates a strong entry barrier and allows lesser number of players to enter the market. Lesser players mean lesser competition and lesser competition means reduced efforts to improve the quality standards.

There are other two constraints which pertain to maintaining the standards of quality. **First constraint is** poor infrastructure for storing raw food materials. Two main types of storages – the warehouses and the cold storages, lag in storage standards. The pests infest the grains sometimes due to lack of monitoring, proper use of pesticides and proper ventilation. Similarly, the power outages result in sub-optimal function of the cold-storages and the quality of food material in the cold storages becomes questionable. **The second important** aspect is having poor quality standards and control methods for implementing the quality standards for processing and packaging the processed foods. For example, vegetables may not be washed properly and processed into either 'ready to eat food' or packaged as 'cut and ready to cook' vegetables.

Also, continuity of quality power, good quality of water for processing, instruments for rapid and reliable analysis, versatile instruments/equipments for multi commodity, cultivars are not suitable for specific processing, etc. are other limitations for food processing industry.

Unless these important constraints are addressed it will be difficult to break the cultural barrier where people prefer fresh food over packaged food. It will be difficult to gain customer confidence and the perceived growth of this industry may actually not be so lucrative.

Food processing overview: Indian scenario

Annually, India **produces 205 million tons** fruit and vegetables, and is the second-largest country in the world as far as farm production is concerned. However, it **processes just 4.6 per cent** of its output. In contrast, countries like the United States (65 per cent), China (23 per cent) and Philippines (78 per cent) are far ahead of India in reducing wastage and enhancing the value addition and shelf-life of the farm products. The fact that a large volume of India's agricultural output is wasted is an alarming signal for the country.

- About 35 per cent of the fruit and vegetables are wasted annually, due to poor storage facility, amounting to a revenue loss of Rs 500 billion.
- Approximately 80 per cent of the vegetables rot due to their high water content and the lack of processing facility, resulting in revenue loss of Rs 125 billion.
- India aims to increase the processing level to 20 per cent by 2015 [Ministry of Food Processing Industries (MoFPI), 2011].

I consider the food processing sector an extension of agriculture sector. Both are interdependent on each other for their progress. In developed countries, the developments in the food processing sector have created a demand in the agriculture sector. India will follow the same path.

Food processing is a process which results in the transformation of raw ingredients obtained from farmers into manufactured food products sold in the retail space. Depending on the level of processing and the degree of value addition, **processed foods can be classified as primary, secondary or tertiary.**

Primary foods (such as packaged fruits and milled rice) undergo a quick and simple transformation. Secondary and tertiary processing (such as preparing bread from wheat, cheese from milk and pickles from vegetables) is a high value-add process involving complex and longer techniques, and result in a complete change in the raw materials.

Indian food industry

The Indian food industry is projected to grow from $100 billion to $300 billion by 2015, according to a report by a leading industry body and Technopak. During the period, the share of processed food in terms of value is expected to increase from 43 per cent to 50 per cent of the total food production.

The food processing industry is of enormous significance for India's development, as it has efficiently and effectively linked the nation’s economy, industry and agriculture. The linking of these three pillars has synergised the development process and promoted the growth of the nation to a great extent.

There are 25,367 registered food processing units in the country, with total invested capital of Rs 84,094 crore ($17.81 billion), as per a competitiveness report of the National Manufacturing Competitiveness Council. The food processing sector is presently growing at an average rate of 13.5 per cent per annum. The Vision Document 2015 envisages increasing the value addition from 20 per cent to 35 per cent by 2015.

The food processing industry is one of the largest industries operating in India and is divided into several segments, including fruit and vegetables; meat and poultry; dairy; marine products, and grains and consumer foods (which includes packaged foods, beverages and packaged drinking water).

The fruit and vegetable processing industry is highly decentralized, but a large number of units are in the cottage, household and small-scale sectors, having small capacities of up to 250 tons per annum. Since 2000, the food processing industry has seen large growth in ready-to-serve beverages, fruit juices and pulps, dehydrated and frozen fruit and vegetable products, pickles, mushrooms and ready-mix vegetables. These small-scale units engaged in these segments of processing are export-oriented.

The value-addition of food products is expected to increase from 8% to 35% by 2025.

Fruit and vegetable processing is also expected to increase from the current level of 4% to 25% of total production by 2025, as per the CCI (Competition Commission of India) report.

The dairy sector, which has the highest share in processed food market, has large unexploited potential. The report revealed that 37 per cent of the total dairy produce is processed, of which only 15 per cent is done by the organized sector. Hence, there are abundant opportunities for investment and development.

The food processing industry in India attracted foreign direct investment (FDI) worth $1,273.96 million between April 2000 and June 2011, according to data provided by the Department of Industrial Policy and Promotion (DIPP).

What is food processing industry (FPI)?

Right from the cultivation and harvest of crop, upto the consumption of product by consumer, there is certain degree of value addition in every product. This value addition can be of numerous types. As it goes from producer, to wholesaler, to retailer and finally to consumer, every stage adds some value to the product. In this value chain there may be value addition by Sorting, grading, packaging, branding etc. These activities not makes product attractive, more usable, gives choice and awareness to customers and also enhances shelf life of products. Apart from this service rendered by intermediaries to pass on product from producer to customer is also valuable.

Most of the agricultural products are not consumable in their original form, for which they are processed. Wheat is converted into flour, Paddy into rice, sugarcane into jiggery, Sugar, ethanol, alcohol etc. These products can be further processed such as flour into bread. Apart from this, left over part of crop such as risk husk can also be processed to get some useful product for e.g. Rice Bran oil, cattle feed, Sugarcane bagasse can be used for power cogeneration.

Hence, food processing not merely adds value to the agro products, but also increases their utility. We know that activities in an economy are broadly divided into Agriculture, industry and Services. Food processing Industry is the product of agriculture and Industry.

Where India stands and why food processing is important?

India Food Processing Industry is estimated at $135 billion industry which is growing at about 8% annually. This growth rate is significantly more than agricultural growth rate which remains around 4%. These signals indicate toward phenomenal shift toward food processing from traditional ways. GDP by processing constitute about 10% that of agriculture. But given potential of India, this is an underachievement.

India has about 26 types of different climatic conditions, 46 varieties of soils are there in India out of total 60 types of soils worldwide. 127 ‘agro climatic zones’ have been identified in India. Also, Indian food is known worldwide for its unique taste and aroma.

India's regional and cultural diversity is perfectly reflected in food. Every state in India has something unique to offer. For e.g. South Indian, Gujrati, Bengali, Rajasthani and Punjabi delicacies are different and are admired in many parts of the world. But they haven't been able to make inroads in other countries the way Mc Donald's, Domino's etc. has done in India. This is because lack of creativeness, innovation, branding and most importantly shallow pockets of Indian manufacturers.

India is -

- **largest producer** of Pulses, Mangoes, Banana, Milk, ginger, Buffalo meat and
- **2nd largest producer** of rice, wheat, potato, garlic, cashew nut, groundnut, dry onion, green peas, pumpkin, gourds, cauliflowers, sugarcane, and tea in the world.
- We produce 17 per cent of the global total of vegetables and
- 14 per cent in the case of fruits.
- About 40 percent of the world's mangoes and
- 30 per cent of the world's bananas and papayas are produced in India.
- Further, India has many unique things to offer such as Alphonso Mangoes and wheat of Madhya Pradesh is uniquely protein rich.

No surprise, that India is **net exporter** of agricultural products. But value addition of Indian product remains quite low. Indian Manufacturers haven't moved much ahead in value chain. Say If mangoes are processed in to Mango Juice or pulp; it will result in more value addition, industry, employment, GDP and foreign exchange, but we export mainly mangoes as it is.

Indian agriculture is infested with post-harvest wastage problem. In category of fruits and vegetables it is about 30-40%. Overall, cost of wastage is estimated at about 18% ranging from 50000 crores to 1 lakh crore. Wastage is attributable to several factors including non-availability of facilities for sorting, grading, packaging, storage, transportation, cold chain and low level of processing of agricultural produce. Food processing can halve this loss. Consequently, farmer will able to get more value and consumer will get products cheaper.

Consumption patterns in India are rapidly shifting from cereals to protein rich foods and horticulture. Also India has significant proportion of population which is **undernutrition** (1/3 of population), **stunted and wasted.** Horticulture and fruits are much desirable for this problem and wastage reduction will have decisive impact here.

Food processing has potential to turnaround whole economy. Indian **economy is still agrarian**, because about 55% population is directly dependent upon agriculture. FPI directly targets farming sector as it attempts to create more types of products out of single crop. This will increase demand for farmers and hence more remunerative prices.

India's **demographic dividend** is much talked about and most of this lies in rural India. Indian youth is turning away from agriculture because of low profitability. FPI is perhaps best bet to seize opportunity of demographic dividend. It can give us a genre of progressive rural entrepreneurs. Prosperous countryside will have multiplier positive impact on socio-economic and political problems. In short, FPI can narrow gap between rural and urban India.

Apart from this India's economy is under transition, Income classes are moving upward. Every year millions of households are coming out of poverty to be part of middle class. **Per capita income is Increasing** as GDP growth rate is much higher than population growth rate. This is complimented by **growing urban culture**, nuclear families, working couples. This makes case for processed food compelling. Consumption in India is gradually tilting towards packaged and ready-to-eat foods. Demand is bound to increase, but it has to be seen that to what extent opportunity is seized by Indian industry and how much is left for foreign companies.

FPI is **employment intensive industry**; it can be an answer to jobless growth of past decade. Currently, only 3 % of employment is in FPI, while in developed countries it handles 14% population. Again, much of the employment will be created into rural India. This can remedy problem of distress migration. Growth in direct employment in the organized food processing sector stands at 6 % between 2011-12.

Also, strategic **geographic location and proximity** to food-importing nations (Middle East and Africa) makes India favorable for the export of processed foods.

Last but not the least, world economies are integrating even rapidly year by year. So a country has no option but to remain competitive.

Global scenario

Food processing is one of the largest global sectors at $7 trillion annual production. Look around and you'll find companies of Cold drinks, Wafer chips, Juice, restaurant chains to be among biggest ones. Italian pasta and pizza is now consumed in almost all countries, so are the burgers and sandwiches. Sugar free products, cornflakes, oats, ketchups etc. are among most demanded consumer goods. Currently only 2 % of India's vegetable and fruits production is processed. In comparison USA and China processes their 90% and 40% produce. Other developing countries, such as Thailand, Philippines, and Brazil are processing as high as 30, 78 and 70% of their produce.

India's food processing sector **ranks fifth in the world** in exports, production and consumption.

Importance of this sector is significant and it deserves a priority treatment by government. Accordingly sector has been made part of ambitious 'Make in India' initiative.

Infrastructure

Supply Chain – Any product is mobilized from producer to consumer to be consumed. This route is called supply chain. This movement involves both time and costs. Lengthier supply chains will push prices upward and result in more wastage. Adequate storage facilities, direct farming, contract farming and negotiable warehouse receipt system are mechanisms to streamline, strengthen and shorten the supply chain.

Apart from these issues other major interventions and investments are needed in infrastructure sector, which is backbone of food processing industry. We have seen that India is biggest producer of numerous fruits and vegetable. Most of these are perishable and have very low shelf life. This is the major reason for high percentage of wastage. Their shelf life can be increased by adequate investment in infra such as cold storage, reefer vans, radiation plants etc.

Storage of foodgrains – FCI deals only in food grains and about 67 per cent of the storage capacity is concentrated in the six major procuring states namely, Punjab, Haryana, Uttar Pradesh, Andhra Pradesh, Rajasthan and Uttrakhand. Several States have emerged in recent years as important states for foodgrains procurement, namely, Bihar, Odisha, Jharkhand, West Bengal, Madhya Pradesh and Chhattisgarh presently account for 13 per cent of the current storage capacity.

Under the National Storage Policy, the bulk grain handling facilities are now being created on the Built Own Operate (BOO) basis at identified locations in the country. Much of the problem here can be relieved by timely offloading of stocks.

Storage of Horticulture products – Mainly NAFED – it also owns godowns and cold stores.

India is currently having severe shortage of cold storage facilities. Significant majority of cold storage facilities were created between 2000 and 2011, assisted to some extent by interventions from National Horticultural Board (NHB), National Horticultural Mission (NHM), Horticulture Mission in North East and Himalayan States, Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Food Processing Industries and Department of Animal Husbandry & Fisheries.

Cold stores are to some extent product specific. Majority of the cold stores in India are dedicated to potatoes. There are some that provide storages for chilies, dry fruits, spices, vegetables etc. Cold storage for meat, fish, milk and milk products and for other commodities such as spices account for only 1 percent of the total cold storage capacity. These cold storages are also usually smaller in capacity.

Nearly 96 per cent of cold storages are in the **private sector** and about 75 percent capacity of cold storages is used to store only potatoes while another 23 per cent fall under the multi-product category.

Value addition

Upstream and downstream/ forward backward integration (in supply chain)

Suppliers to a producers or trader lie on upstream side, where as customers lies on downstream side. This will change according person under observation. For a farmer, supplier of seeds and fertilizers lie on upstream, while cold store owners, farm contractors, mill owners, traders in agro output lies on downstream.

Suppliers (seeds, fertilizers)

upstream value addition

producers or trader (farmer)

downstream value addition

Customers (cold store owner,
farm contractors,
mill owners,
traders in agro output)

When a particular person in supply chain assume role of two levels it is said integration. If PepsiCo instead of procuring potatoes (for chips) from farmers get potatoes captively from its own lands, it will be called backward integration. On other hand if farmer puts up a processing plant for chips, or a cold storage, this will be called forward integration. Direct farming is also a forward integration, where farmer assumes role which was played by commission agent in APMC (Agriculture Produce Market Committee).

get potatoes captively from its own lands ← backward integration — PepsiCo

farmer — forward integration → puts up a processing plant for chips

Forward and backward integration, also called vertical integration, is common in any business and it saves the costs associated with supply chain. Business which pursues integration strategy, earns a competitive edge. For example Reliance Industries owns oil and exploration business, refining business, retail outlets for petro products, and is India's biggest polyester manufacturer. Consequently RIL has almost monopoly in these sectors.

In farming and food processing, vertical integration can work wonders. For this farmer needs financial and technical support. Agriculture in India already is overemployed. This with seasonal nature of majority of farming crops gives farmers a compelling reason to get into food processing business.

Institutions

1. **Ministry of Food Processing Industries (MOFPI)** – formed in 1988

a) The Ministry is nodal agency for FPI and is concerned with **formulation and implementation** of the policies & plans for the food processing industries within the overall national priorities and objectives.

b) Facilitating **creation of a conducive environment** for healthy growth of the food-processing sector.

c) Creation of **World Class Infrastructure**

d) Promotion of **R&D** in Food Processing sector

e) Human Resource Development to meet the growing requirement of managers, entrepreneurs and skilled workers

f) Assistance for setting up **analytical and testing laboratories**, active participation in the laying down of food standards and their harmonization with international standards.

g) Continue intensive **consultation** with industry, academia, scientists and representatives of State Governments

h) Has set up a national level institute of International standard – **National Institute of Food Technology Entrepreneurship and Management (NIFTEM)** at Kundli in Haryana

i) Decentralisation in the implementation of various schemes with greater involvement of the States/UTs. The Ministry has launched a new Centrally Sponsored Scheme-National Mission on Food Processing (NMFP) with effect from 01.04.2012.

2. **Agricultural and Processed Food Products Export Development Authority** (***APEDA***) – an apex organization under the **Ministry of Commerce and Industry –** focus on 'export' of scheduled products

Authority was established in 1985, by an act passed in parliament. Main functions are –

a) Development of industries for export by way of providing **financial assistance** or for **undertaking surveys and feasibility studies**, participation **through joint ventures** and other **subsidy schemes**

b) **Registration of persons as exporters**

c) Fixing of **standards and specifications** for the products for the purpose of exports;

d) Carrying out **inspection of** meat and meat products in slaughter houses, processing plants, storage premises, conveyances or other places where such products are kept or handled for the purpose of ensuring the quality of such products;

e) Improving of **packaging** of the products;

f) Improving of **marketing** of the products outside India;

g) Promotion of export oriented production and development of the products;

h) Training in various aspects of the industries connected with the products;

APEDA
has set up common infrastructure facilities like 'centre for perishable cargo' at various international airports. Facilities such as Vapor Heat Treatment plants, irradiation facilities, integrated pack houses, pre-cooling facilities, and high humidity cold stores for specific horticulture products are also there.

Additionally, it provides financial support to exporters for installing facilities such as Reefer Vans and in-house above mentioned facilities.

Similarly, Marine Products Export Development Authority (MPEDA) is there for fishery production and related activities.

3. **Department of Animal Husbandry, Dairying & Fisheries**

The Department is responsible for matters relating to livestock production, preservation, and protection from disease and improvement of stocks and dairy development, and also for matters relating to the Delhi Milk Scheme and the National Dairy Development Board. It also looks after all matters pertaining to fishing and fisheries, inland and marine.

The Department advises State Governments/Union Territories in the formulation of policies and programs in the field of Animal Husbandry, Dairy Development and Fisheries.

4. **National Horticultural Board (NHB) under –** Ministry of Agriculture

The broad aims & objectives of all the above mentioned schemes are as under: –

A) Developmet of **hi-tech commercial horticulture** in identified belts

b) Development of **modern post-harvest management infrastructure** as integral part of area expansion projects or as common facility for cluster of projects

c) Development of integrated, energy **efficient cold chain infrastructure** for fresh horticulture produce,

d) **Popularization of identified new technologies / tools / techniques** for commercialization / adoption, after carrying out technology need assessment,

e) Setting up '**Common Facility Centers'** in Horticulture Parks and Agri-Export Zones

f) Transfer of technology to producers/farmers and service providers such as gardeners, farm level skilled workers, operators in cold storages, work force carrying out post-harvest management etc.

FDI in food processing

5. 100% FDI is permitted in the automatic route for most food products except for items reserved for micro and small enterprises.

6. 100% FDI is permitted for alcoholic beverages, with the requirement of an industrial license.

7. For pickles, mustard oil, groundnut oil and bread – items reserved for the micro small and medium sector, 24% foreign direct investment is allowed under the automatic route, with the requirement of prior approval from the Foreign Investment Promotion Board for FDI amounting to more than 24%.

Vision 2015

Vision 2015 which was adopted in 2010 provides for

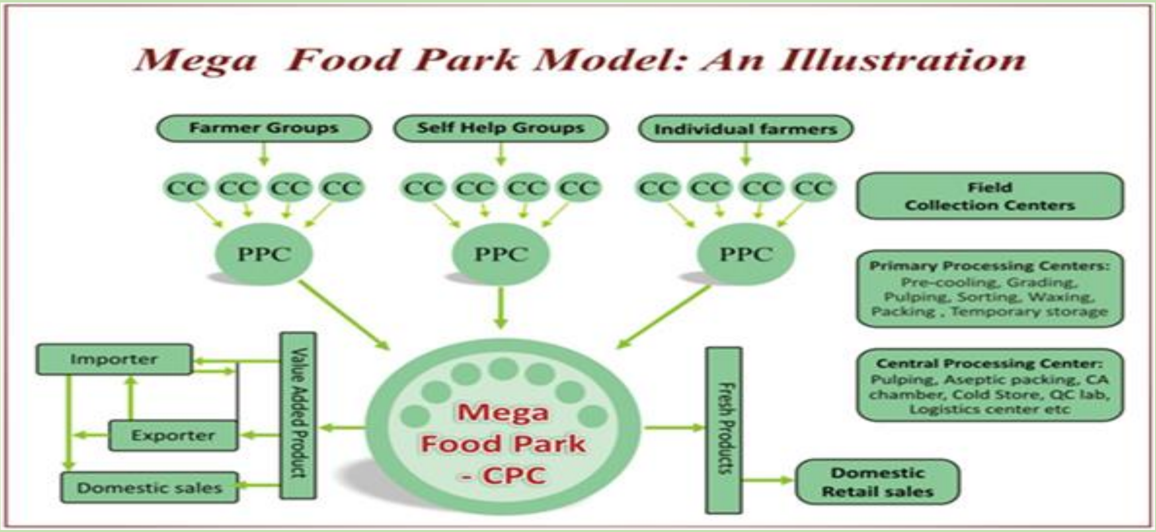
- **enhancing the level of processing of perishable** to 20%,
- **enhancing value addition** from 20% to 35% and
- **increasing India's share in global food trade** from 1.5% to 3% by the year 2015.

To achieve these targets, investment of Rs.100 thousand crores was estimated by year 2015, out of which Rs.10000 crores was to come from the Government. Vision 2015 provides for **establishment of 30 Mega Food Parks in public-private partnership**, so far 21 such projects have been approved and approval of 4 projects is pending. **1st Mega Food Park to open was in Sirni food park in Andhra.** Recently 'Tumkur Integrated Food Park' was inaugurated in Karnataka. This is the first integrated food park which has been developed with partnership from the Ministry of Food Processing Industries, and the State government. Now list of mega food parks to be set up has gone up to 42, since make in India initiative.

Mega Food Park Scheme

As envisaged by vision 2015, Mega Food Parks, are to be based on 'cluster approach'. In India there are regional horticultural crops, which are dominantly grown in a particular area. In these areas there is generally cluster of similar farmers, factories, and traders etc. who dominantly deal in same agro product. Scheme aims to strengthen such clusters by providing world class infrastructure facilities. This will result in smoothening of supply chain – '**Farm to Market'.**

Hub and spoke model is adopted, as per which there will be a strong Central Processing Unit, which will cater needs of surrounding areas. In surrounding areas, there will be smaller, 'primary processing centers' which will be fed from numerous 'collection centers'. These collection centers will have direct interface with the farmer, farmer groups, or self-help groups.



This will lead to **vertical integration** (backward and forward integration) in activities of that particular area.

Central Processing units are to be built under public private partnership. Area for will range from 50-100 acres, though the actual requirement of land would depend upon the business plan, which may vary from region to region.

Onetime capital grant of 50% of the project cost (excluding land cost) subject to a maximum of Rs. 50 crore in general areas and 75% of the project cost subject to a ceiling of Rs. 50 crore in difficult and hilly areas, is available.

Program Management Agency is appointed by the Ministry to provide **management**, **capacity building**, **coordination** and **monitoring support**. For meeting the cost of the above and also other promotional activities by the Ministry, a separate amount, to the extent of 5% of the overall grants available, is earmarked.

It is expected that on an average, each project will have around 30-35 food processing units with a collective investment of Rs.250 crores that would eventually lead to an annual turnover of about Rs.450-500 crores and creation of direct and indirect employment to the extent of about 30,000 persons.

Special Purpose Vehicle

The execution, ownership and management of the Mega Food Park are vested with a Special Purpose Vehicle (SPV). SPV shall be a body corporate (company) registered under companies act.

Special Purpose Vehicle is term commonly used in corporate world. It mobilizes funds, expertise and experience of more than one organization toward a common goal. For example a company will be formed by pooling funds of interested parties and this company will be called SPV.

Definition, functions etc. of SPV can differ from case to case. In this case it is responsible for ‘execution, ownership and management’ of Mega Food Parks.

Special Fund in NABARD

Government of India instituted a Special Fund in National Bank for Agriculture and Rural Development (NABARD) with a corpus of Rs. 2000 Crore during 2014-15 for providing direct term loans to establish infrastructure in the Mega Food Parks as also to the individual processing units to be set up in the designated Food Parks, at affordable rate of interest of around 10% p.a. The designated Food Parks would include Food Parks promoted by the Ministry of Food Processing Industries (MoFPI) or State Governments; Mega Food Parks promoted by MoFPI; food processing units set up in the Special Economic Zones or any other areas having developed enabling infrastructure and designated as Food Park by the MoFPI.

Scheme of Cold Chain, Value Addition and Preservation Infrastructure (Cold chain facility)

It aims to facilitate the establishment of a strong cold chain facility for agricultural, horticultural, dairy, fish & marine, poultry & meat products by establishing linkage from farm gate to the consumer, end to end, to reduce losses through efficient storage, transportation and minimal processing.

Its components are:

Processing Centre at the farm level and centers is to have facility for weighing, sorting, grading waxing, packing, pre-cooling, Control Atmosphere (CA)/ Modified Atmosphere (MA) cold storage, normal storage and Individual Quick Freezing (IQF).

Mobile pre-cooling vans and reefer trucks.

Distribution hubs with multi products and multi Control Atmosphere (CA)/ Modified Atmosphere(MA) chambers/ cold storage/ Variable Humidity Chambers, Packing facility, Cleaning in Process (CIP) Fog treatment, Individual Quick Freezing (IQF) and blast freezing.

Irradiation facility

Financial assistance of 50% the total cost of plant and machinery and technical civil works in General areas and 75% for NE region including Sikkim and difficult areas (J&K, Himachal Pradesh and Uttrakhand) subject to a maximum of Rs.10 crore.

Cold Chain for Non-Horticulture Products is also being funded under National Mission on Food Processing which provides Capital subsidy of 35% of cost of project or Interest subvention by 6% (max 5 crore). Also subsidy of 50% is available on investment in 'reefer vehicles' (max. 50 lakhs).

NABARD too provides concessional finance for construction of warehouses, godowns, silos and cold storage units.

Modernization of Abattoirs (slaughterhouse)

This is a comprehensive scheme, which includes establishment of modern abattoirs and modernization of existing abattoirs. Modernization of abattoirs will also include upscaling of infrastructure of existing abattoirs. The scheme is implemented with the involvement of local bodies and has flexibility for involvement of private investors on PPP basis.

The scheme envisages a grant of 50% of the cost of plant and machinery and technical civil works subject to a maximum of Rs.15.00 Crores in general areas and 75% of the cost of plant and machinery and technical civil work and other eligible items subject to a maximum of Rs. 15.00 Crores in difficult areas.

Agri Export Zones

To give thrust to export of agro products, new concept of Agri Export Zones was brought in 2001. APEDA has been nominated as the Nodal Agency to coordinate the efforts on the part of Central Govt. negotiations.

Entire effort is centered on the

- cluster approach of identifying the potential products,
- the geographical region in which these products are grown and
- Adopting an end-to-end approach of integrating the entire process right from the stage of production till it reaches the market. (farm to market)
- There would also be a need to identify/enlist difficulties/ problems encountered at each stage
- Identification of such potential crops is responsibility of state governments. Projects in such areas for identified crops will be eligible for financial assistance and certain fiscal incentives.

Financial Assistance – example -These extend from providing financial assistance for Training and Extension, R&D, Quality Upgradations, Infrastructure and Marketing etc.

Fiscal Incentives – example -The benefits under Export Promotion Capital Goods Scheme, which were hitherto available only to direct exporters, have now been extended to service exporters in the Agri Export zones.

Under this scheme import of capital machinery will be allowed at concessional custom duty, provided importing units commits to export of certain quantity of agro products after commencement of production.

Currently there are about 60 Agri Export Zone. Checkout which one is in your region here.

Apart from this National Mission on Food Processing is in place since 2012, which subsumed a number of schemes. Main objective of the mission is to decentralize implementation of food processing related schemes to States.

Other initiatives by government –

- National Food Processing Policy – Target 2025 – increase food processing to 25% of agro produce.
- Food Processing is recognized as a priority sector for Bank lending.

Role of small scale sector

The small scale and unorganized sector constitutes about 70% of the food processing sector. Employment intensity is significantly higher in this sector as compared to the organized sector for the same level of investment.

Unfortunately, sector suffers from low efficiency due to the lack of – access to credit, managerial knowledge, efficient tools/ technology, marketing network etc. Intense competition from large scale players has also affected it.

Further, in export too dominance is of small scale sector. Due to financial constraints they fail to add much value to the products. Real value adding processing happens to most exported products abroad. These products have very low brand value. Lastly, small scale industry is extremely risk averse, afraid of trying new products, technologies, markets.

In contrast global companies in competition are giants such as Pepsi, Kellogg's etc. These companies have huge economies of scale, influence in International politics and invests substantial amount in R&D.

At the processing stage small scale industry needs targeted programs to improve productivity, access to technology, credit and downstream markets. This will also enable reduced wastage and nutrition losses in processing. Potential programs could include financial assistance for procurement of machinery, credit, technical advice on productivity improvement and machinery selection and trainings on adopting standardized processes. Many of these initiatives are already there on part of the government, but information deficit and risk avoidance comes in the way.

To achieve these objectives to some extent, it is imperative that supply chain infrastructure be built. Organized sector has capacity to build this Infra, which can also cater to needs of Small scale sector.

Government has reserved certain Items exclusively for small scale industries which includes pickles, chutneys, bread, confectionery, rapeseed, mustard, sesame oils, groundnut oils, ground and processed spices, sweetened cashew nut products, tapioca sago and tapioca flour.

Cooperative sector experiments can also bring small scale sectors into organized form as was seen in success of AMUL and Lijjat Papad managed by cooperative named Shri Mahila Griha Udyog Lijjat Papad.

Safety, Hygiene and regulations

Extensive use of fertilizers, pesticides and other chemicals has raised concerns about quality of food. Further, protection is needed from unfair and hazardous practices such adulteration, Synthetic milk and milk products etc. For this Food Safety and Standards Act was enacted in 2006 prior to which there were plethora of laws under different ministries, which were overlapping and confusing. FSSA was aimed at providing single point reference for all matters relating to food safety and standards.

Food Safety and Standards Act 2006

- Ministry of Health & Family Welfare has been designated as the nodal Ministry for administration and implementation of the Act
- Act established an independent statutory Authority – the Food Safety and Standards Authority of India with head office at Delhi. These along with State FSSAs secure compliance of various provisions of the act.
- Framing of Regulations to 'lay down the Standards and guidelines' for articles of food and specifying 'appropriate system of enforcing' various standards so laid.
- Laying down mechanisms and guidelines for accreditation of certification bodies engaged in certification of food safety management system for food businesses.
- Laying down procedure and guidelines for accreditation of laboratories and notification of the accredited laboratories.
- To provide scientific advice and technical support to Central Government and State Governments in the matters of framing the policy and rules in areas which have a direct or indirect bearing of food safety and nutrition.
- Collect and collate data regarding food consumption, incidence and prevalence of biological risk, contaminants in food, residues of various, and contaminants in foods products, identification of emerging risks and introduction of rapid alert system.
- Creating an information network across the country so that the public, consumers, Panchayats etc. receive rapid, reliable and objective information about food safety and issues of concern.
- Provide training program for persons who are involved or intend to get involved in food businesses.
- Contribute to the development of international technical standards for food, sanitary and phyto-sanitary standards.
- Promote general awareness about food safety and food standards.

The Sanitary and Phytosanitary Measures Agreement (SPS agreement)

This agreement was one of the results of Uruguay Round of negotiation entered into force with the establishment of the World Trade Organization on 1 January 1995. The Agreement sets out the basic rules for food safety and animal and plant health standards. It allows countries to set their own standards. But it also says regulations must be based on science. They should be applied only to the extent necessary to protect human, animal or plant life or health. And they should not arbitrarily or unjustifiably discriminate between countries where identical or similar conditions prevail.

CODEX

Codex Alimentarius Commission is an international agency on food standards in which almost all members of WHO, and Food and Agriculture Organization of United Nations (FAO) are members. These members agree to adopt standards on food established by CODEX. There is also reference, endorsing use of CODEX standards, in WTO's SPS agreement.

Any member nation willing to set standards over and above CODEX will have to give scientific justification and explanation for that matter.

Hazard Analysis and Control Critical Point (HACCP)

HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards — from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

This system is recommended by CODEX and used by it for setting standards.

International Standards Organization (ISO)

ISO is international independent organization, engaged in formulation and setting up of standards for different products including processed food products. It has overtime become a brand and products marked with ISO enjoys premium in markets. It should be noted that ISO standards are not something which is enforced by government, WTO, WHO etc. It is purely voluntary on part of manufacturer.

ISO doesn't certify itself; there are other entities which certify. ISO just set standards.

'ISO 22000' deals with 'food safety management' and 'ISO 14000' deals with environmental impact

Food safety and hygiene is critical for development of sector. In era of intense global competition countries implement these standards jealously to guard their domestic industries. These sometimes get converted into non-tariff barriers.

Recently, India Alphonso mangoes were banned by European Union due to the presence of harmful pests and a lack of certification before export.

To overcome this problem MOFPI runs scheme of 'R&D, quality, CODEX and promotional activities'

This scheme includes financial assistance and technical support for –

- Setting up/up-gradation of quality control centers or Food testing labs
- Implementation of quality assurance mechanisms such as
- Total Qty. Management (TQM) including ISO 14000, ISO 22000, HACCP, GMP, GHP

- R&D is food processing sector
- Other promotional activities

Food Irradiation – (the application of ionizing radiation to food) is a technology that improves the safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects. Like pasteurizing milk and canning fruits and vegetables, irradiation can make food safer for the consumer.

THE BENEFITS AND LIMITATIONS OF RADIATION PROCESSING OF FOOD

Benefits	Limitations
Radiation processing is a cold process and therefore, unlike heat, it can be used on agricultural commodities without changing their fresh-like character	Radiation processing is a need based technology and cannot be applied to all kinds of foods
Radiation processing dose not alter significantly nutritional value, flavor, texture and appearance of food	Radiation processing cannot make a bad or spoiled food look good
Radiation using Cobalt-60 cannot induce any radioactivity in food and does not leave any harmful or toxic radioactive residues on foods as is the case with chemical fumigantsd	It cannot destroy already present pesticides and toxins in foods
Due to the highly penetrating nature of the radiation energy, it is a very effective method	Amenability of a particular food commodity to radiation processing has to be tested in a laboratory
Prepackaged foods can be treated for hygienization and improving shelf-life	Only those foods for which specific benefits are achieved by applying appropriate doses, and those duly permitted under the Prevention of Food Adulteration Act (PFA) Rules, 1955, can be processed by radiation.
The radiation processing facilities are environment friendly and are safe to workers and public around	

Interestingly, Bhabha Atomic Research Center (BARC) offers ‘ AKRUTI Technology Package for Rural development’ which provides infra and knowhow for radiation facilities.

Food processing seems to have promising future, provided adequate government support is there. Food is the biggest expense for an urban Indian household. About 38 % of the total consumption expenditure of households is generally spent on food. This share is declining consistently. As mentioned, food processing has numerous advantages which are specific to Indian context. It has capacity to lift millions out of undernutrition. Government has challenge to develop industry in a way which takes care of small scale industry along with attracting big ticket domestic and foreign investments.

UNIT 2

QUALITY REQUIREMENT OF RAW MATERIAL FOR PROCESSING PLANTS

Introduction

The quality of raw materials is crucial to ensure the safety and quality of the final product after preservation. Therefore, this chapter shall focus on the criteria for selection and purchase of foods which need to be preserved.

The foods generally preserved are those foods which tend to get spoiled fast after harvest or slaughter i.e. the perishable and semi-perishable foods. On the contrary, non-perishable foods require less attention as they are to be just kept in cool, dry place for longer shelf life.

Selection and Purchase of Perishable Foods

The perishable foods include milk and milk products, meat, fish, poultry, fruits, and leafy vegetables. One criterion for selection of perishable foods is that these must be fresh. In practice this means milk freshly drawn, fish freshly caught from a river or sea, meat soon after slaughter, eggs just laid, vegetables just harvested from the garden and fruits just picked from the tree. As far as possible perishable foods should be used fresh or must be kept under refrigeration till further use to maintain their quality. Purchase perishable foods last and take home quickly to refrigerate.

Selection criteria for milk and milk products

Following points should be considered while choosing good quality milk and milk products:

- Fresh milk has a slightly sweetish odour and flavour, is white in colour and has a faintly acid reaction to litmus. Stale milk has a sour odour, flavour and curdles when heated. Do not choose milk which tastes sour or bitter.
- Any sample of milk, buttermilk or curd having a frothy, bubbly surface, rope formation; discolouration and fat separating out into clumps should not be purchased.
- Smell gives a good idea of quality of milk and milk products. The milk and milk products therefore should bear their characteristic smell.
- Good quality butter is made from high-quality fresh, sweet cream and has delicate, sweet flavour, with a fine, highly pleasing aroma and smooth, creamy texture with good spreadability. Butter tasting rancid should be discarded.
- Good quality paneer shall have a soft texture with a natural white colour. It should not have off flavour or show any signs of spoilage like mould growth and slimy surface etc.
- Cheese and curds with off-flavours, mould growth and slimy surface should not be chosen.
- Fresh khoya has a sweet delicate aroma and taste. Stale khoya has a rancid odour and a flat taste. Buffalo milk is preferred over cow’s milk in preparation of khoya, as the former gives it soft body and smooth texture.

Selection criteria for meat, poultry and fish:

The kinds and forms of flesh foods available include lamb, mutton, poultry, pork and fish. The general considerations which are to be kept in mind while buying meat are as given below:

- When shopping, place packaged raw meat, poultry and fish in plastic bags and keep away from contact with other foods.
- Meat: Meat is selected on the basis of conformation or form, finish and quality. Conformation or form refers to the shape or build of the animal. Good form consists of short, thick, compact build, with large muscles, which have high proportion of meat to bone. Finish indicates the amount and distribution of fat. An even layer of fat on the outside of the carcass and even distribution of fat in the lean part are indicators of a good finish. In good quality meat, three aspects are observed, such as, lean meat is bright red in colour, when cut surface is exposed to air; it is fine grained and smooth to touch, and the fat is firm, brittle and creamy white in colour. Meat prices vary according to the cut, quality and kind. Selection is made according to the intended use in preparation.
  - Meat should be bought from a clean and hygienic shop and should be free from bad odour.
  - Meat should be refrigerated after slaughter, until it is sold/ preserved.
  - Slime on the surface of meat indicates deterioration.
  - Meat should have deep red colour with white or creamy fat. Very dark brown or green colour and yellow fat are the signs of poor quality meat. When the meat is greenish and smells bad it is of poor quality and not safe for eating.

Poultry: In poultry, there is a relatively high proportion of waste from live weight to edible portion. Edible portion is only about 55 per cent of live weight. Selection is made on the basis of intended use of the poultry. In a young bird, the skin and breast-bone are pliable, soft and tear easily. Older birds have hard calcified breast-bone and may have a lot of long hair. Weight is not necessarily related to the age of the bird. In young birds sex difference is not significant, but older male birds are less fatty and are inferior in flavour to female birds. Poultry which is dressed, should be properly refrigerated.

- Good quality poultry is full fleshed, meaty legs and breasts and has a good layer of fat. The skin is smooth, without tears and discolouration or pin feathers.
- In general, while buying chicken ensure that the skin of the chicken is soft and tear easily
- The breast bone should bend easily. If one twists the wing it should break at the shoulder joint. Select female birds, as they are juicier and less tough.

Eggs: Eggs are sorted according to size. Large eggs are preferred for table use. When eggs are used in preparation, size is not important and selection is made in terms of price in relation to size. to purchase fresh, clean and unbroken eggs.

- It is advisable buy fresh, clean eggs with unbroken shell.
- A fresh egg will sink in water.

Pork: The best quality of pork has muscle that is grayish white to pink in young and deep rose in older animals. The flesh is firm and fine grained and the bones are soft and red. It has a minimum of fat. Lower quality pork is heavier and contains more fat.

Fish: It should have firm flesh and bright skin with a lot of well adhering scales. It must have bright, clear and unsunken eyes and red shiny gills like fresh blood.

- Disagreeable colour and flesh that leaves a dent when pressed and dry skin in fish are signs of spoilage.
- Skin should have little shine and body must be stiff.
- As a rule, if placed in water, the fish will sink and it is considered good.
- Stale fish would float on water, so avoid them.
- Be sure to purchase fish, which has been refrigerated or stored on ice, and is not slippery or slimy to touch.
- Frozen fish should be frozen solid when purchased, and should have no odour. It should be wrapped in water proof packaging material. It should be kept frozen until use.

Selection Criteria for Fruits

In order to select fruits fit for preservation purposes, knowledge of ripening process in fruits is essential. During ripening of fruit, fruit develops to its full size, the pulpy edible tissue becomes soft and tender, the colour of fruit changes, and the starch content changes to sugar giving a mild sweet flavour and full characteristic aroma of the fruit develops. Changes beyond this point cause spoilage and deterioration of texture and flavour.

Efficient selection of fruit involves consideration of size, grade and variety. Size and grade of fruit are major determinants of the economic value of preserved food product i.e. net edible portion of fruit available for use in making a preserved product. Fruits of lower grade are less expensive but the waste may compensate the price advantage. Each fruit has different varieties and each variety has its special characteristics. For example- some varieties are good for preservation while some are good only for eating. Fruit price is not always indicative of quality or its nutritive value.

Climacteric fruits are those which ripen after being picked whereas non-climacteric ones do not. Climacteric fruits include apricots, bananas, kiwi, peaches, pears, plums, watermelon, mangoes, figs and tomatoes etc. and these can be purchased when unripe. But non- climacteric fruits like apples, cherries, grapefruit, grapes, oranges, pineapple and strawberries etc. should be purchased when fully ripe.

- The quality of fresh fruits can be judged reasonably well by their external appearance. In purchasing fruits, it is necessary to learn to judge the appropriate size and colour for the kind and variety of fruit, as these are indicators of the high quality of the fruit and its maturity.
- Most fresh vegetables and fruits retain their freshness for a short time under ideal conditions of storage. Nutritive value of fruits and vegetables decreases over a period after harvest therefore, one should try to buy those that are fresh.
- Good quality fruits are the ones that are just ripe, crisp, fine and free from bruises. They should not show any signs of spoilage like presence of mould, wilting and limpness, discolouration and mushy texture, presence of insects and worms, overmature vegetables and damaged or bruised skin etc.

- One should select the fruit at its peak of maturity for its sweet preserved preparations. Fruits are selected in unripe state when salty preserved products are to be made.
- Fruits in season are generally cheaper than when not in season and are of better quality than the fruit sold out of season. It is therefore advisable to buy fruits which are in season, as the quality is high and the price low.
- Since the fruits deteriorate more rapidly after they have ripened, one should purchase the fruit in bulk only when he has adequate facilities for storage (preserving) of the surplus fruit. Few fruits like apples can be kept for long period of time but the duration involved in transportation from the place of growing to market should also be kept in mind.
- Bananas: should not have black spots on the skin and be free from bruises and slightly hard when purchased. They should be then allowed to ripen at room temperature, as fully ripe fruit is easily bruised even as you carry it home from the market. Shelf-life of green bananas is very short after ripening. Ripe fruit does not store well in the refrigerator, as the sugar to starch conversion is favoured at low temperature. Best eating quality of bananas has been reached when the solid yellow colour is specked with brown.
- Apples: Good apples are firm, crisp, well coloured and heavy. Each variety has its own characteristic colour and shape. Apples become mealy, have less flavour and taste, when stored too long. Hence, it is advisable to buy apples only in season. Small, tart fruits are suitable for making jelly, sauce and similar preserved foods.
- Grapes: should be plump, shiny, well coloured, firmly attached to stem, free from discolouration and bruises. They should not leak as it is sign of spoilage.
- Citrus fruits: include oranges, sweet limes (mausambi), grape fruits, lemons, etc. These are sorted according to size and the price decreases with the size. These are sold per dozen or per basket, and in some markets lemons are sold by weight. Citrus fruits which are bright and thin skinned, firm, rich in colour and heavy in relation to size are preferred, as these are likely to contain more juice. Dull, dry skin and spongy texture indicate aging and deteriorated eating quality. Also avoid decay, shown by cuts or skin punctures, soft spots, mould on the surface and punctures of the skin , and discoloured, weakened areas of skin around the stem end or button.
- Pears: should be selected when it is firm and already begun to soften to be reasonably sure that they will ripen satisfactorily. They should not be wilted or shrivelled with dull-appearing skin and slight weakening of the flesh near the stem, which indicates immaturity and such pears will not ripen. Also avoid spots on the sides or blossom ends of the pear, which means that corky tissue may be underneath.
- Pineapple: Select pineapple with bright golden yellow, orange-yellow, or reddish brown colour, depending on the variety, which is spread to 15 or 20 per cent of the fruit and are firm, plump, and heavy for their size, with fragrant aroma, and a very slight separation of the eyes or pips. The larger the fruit, the greater the proportion of edible flesh. They should be free from discoloured or soft spots, bruises and mouldiness.
- Plums and prunes: should be selected with a good colour for the variety, in a fairly firm to slightly soft stage of ripeness.
- Peaches: which are fairly firm, not too soft, having skin colour yellowish or at least creamy between the red areas should be selected.

Selection and Purchase Criteria for vegetables

Standards for selection of vegetables vary with the specific commodity. In general, freshness, uniformity of size, variety, colour, degree of ripeness and freedom from defects are the qualities most frequently sought.

- As with fruits at the peak of season, each vegetable has the highest nutrient content, flavour and is available at a reasonable price. Therefore, seasonal vegetables should be preferred.
- Select fresh vegetables which are firm, crisp, bright in colour, with no visible bruises or signs of decay and wilting.
- Vegetables will usually wither when kept in the sun or kept for too long. So buy fresh vegetables.

Leafy vegetables:

- Select clean, young, tender, firm, crisp, brightly green coloured leafy vegetables which are free from flowers, insects, mud and spots or holes in the leaves.
- Do not buy wilted or insect eaten or the ones with white insect eggs on the leaves, which are found on the underside of the leaves.
- Leaves with coarse, fibrous stems, yellowish-green colour, softness (a sign of decay), or wilted condition should be avoided. Also avoid greens with evidence of insects especially aphids which are difficult to wash away.
- Cabbage: In cabbage, the hard, heavy and compact heads free from bruises and worm injury are a good buy.

Roots and tubers:

- When buying root and tuber crops, one should be sure that they are of one variety, well-shaped, smooth and roughly of one size.
- In general, roots and tubers should be firm, heavy, free from bruises, spots, dirt and discolouration.
- Roots and tubers should be free from bruises/ cuts since this makes them rot quickly and the skin should be unbroken and should cling tightly.
- Softness, excessive dirt, scabbiness, sunburn, hollow or black heart, and decay are all objectionable qualities in roots and tuber crops.
- Onions: These should be hard or firm with dry and small necks, reasonably free from green sunburn spots or other blemishes should be selected.
- Potatoes: Select potatoes which are clean, firm, heavy in relation to size, with shallow eyes and are free from sprouts, blemishes, decay and green discolouration. Avoid potatoes with large cuts, bruises, sprouted or shriveled or decay as they will cause waste. Unless early or "new" potatoes are desired, they should be matured.
- Carrots: Select carrots which are well formed, smooth, well coloured, and firm with their green coloured tops.

Other Vegetables:

- These should be generally tender, firm, crisp, bright coloured vegetables free from worm injury.
- Small or medium sized vegetables are likely to be tenderer and less fibrous in texture than large and too mature ones.
- Reject those which are too mature, dry, wilted, shrunken, shrivelled, discoloured vegetables.
- Cauliflower: When purchased should have white to creamy-white, compact, solid, and clean curds Jacket leaves if attached should have good green colour. A smudgy or speckled appearance of the curd is a sign of insect injury, mold growth, or decay, and should be avoided.
- Mushrooms: That are young i.e. small to medium in size should be selected. The surface of the cap should be white or creamy, or uniform light brown if of a brown type. Overripe mushrooms as shown by wide-open caps and dark, discoloured gills underneath and those with pitted or seriously discoloured caps should be avoided.
- Ladies finger: Okra with tender pods (the tips will bend with very slight pressure) under 10-11 cm long. They should be bright green colour and free from blemishes.
- Tomatoes: Select tomatoes which are smooth, well ripened, with an overall rich, red colour and a slight softness and reasonably free from blemishes should be selected.

Selection and Purchase of Semi- and non-Perishable Foods

All cereal and pulse products like wheat flour, semolina, vermicelli, broken wheat, Bengal gram flour, and some fruits and vegetables like citrus fruits, aonla, apples, pumpkin, roots and tubers, yams, potatoes, onions, garlic fall under category of semi-perishable foods. Non-perishable foods include preserved food products (canned, dried, pickled etc.), whole cereal, pulse and millet grains, oilseeds, nuts, fats and oils, honey, sugar, jaggery, salt, whole spices and essence.

Cereals, pulses and oilseeds:

While buying cereal grains, pulses and oilseeds following points should be considered:

- Whole grain cereals, dals and whole pulses are selected on the basis of their appearance, feel, colour and variety. The grains are inspected for uniform size, cleanliness, soundness of grain, absence of broken pieces, freedom from insect infestation, absence of admixture with foreign seeds and trash, dirt, mud, stones and sand.
- The grain can be chewed to detect the texture and flavour. Hollow, soft fibrous texture indicates deterioration in quality. Sour or rancid flavour and odour indicate spoilage during storage.
- Grains should be free from added colouring matter, moulds, fungus or insects, obnoxious (unpleasant) substances, discolouration, poisonous seeds and all other impurities like rodent hair and excreta etc.
- Look for plump looking kernels which are not broken, shrivelled, or insect eaten.
- Cereal grains should be sweet, hard, clean, wholesome, uniform in size, shape, colour and in sound merchantable condition. Ensure that the grains are sound and dried; clean, free from foreign matter i.e. dust, stone, lumps of earth, twigs, chaff, stem or straw, dirt, gravel (small fragments of rock) etc. and any other impurity including non-edible seeds.

- Cereal flours especially pearl millet flour should be freshly ground and should be free from any rancid smell. Ensure that the cereal flour (wheat, jowar, maize) is free from insects, lumps and moulds.
- Nuts and oilseeds must be free from any absorbed or rancid odour and flavour. Freedom from moisture, during storage, is very important to avoid spoilage.

Wheat:

Wheat is processed for making wheat flour, semolina, wheat grits (coarsely ground) etc. Wheat flour is used for making bread, chapatti, biscuits etc. The quality requirements of wheat for various products like chapatti, bread, biscuit and pasta are different.

- Good quality broken wheat(dalia)is indicated by sweet taste and an absence of sour, mouldy odour and flavour.
- Semolina(suji or rawa)is selected on the basis of uniformity of size, freedom from oxidised or mouldy odour, grit or bran.
- Good quality refined wheat flour (maida)is free from insect infestation, bad odours and lump formation.
- For bread making, hard wheat (Triticum durum) varieties such as Bansi and Bakshi (tough grain with 11-15 per cent protein) should be selected as they contain strong gluten and more than 12.0 per cent protein.
- For biscuit making, one should select varieties which contain weak gluten and less than 9.0 per cent protein. Khapli variety of wheat is in demand nationally to make biscuits as it has more protein and less starch.
- For pasta products, hard wheat with strong gluten, more than 12.5 per cent protein is required. Wheat varieties like Sarbati, Lok -1, Sehore (also known as Lahandosh or Chandoshi), Bansi, Bakshi, Khapli, and Black Wheat have excellent chapat>ti making quality.

Rice:

Rice is used in various kinds of processed products like rice flakes, puffed rice, papads, extruded products. The criteria for selection of rice for making such products is given in following text.

- Rice flakes should be free from bran, broken particles, fragments of the seed coat, insects, stones, trash and bad odour.
- Puffed rice is selected for crispness, freedom from stones, seed coats, sand and dirt. High amylase varieties of rice are not suitable for making puffed rice.

Pulses:

Preserved products like dehydrated products such as papad, wadi etc. prepared from pulses. Roasted chana dal is selected for crisp texture, sweet flavour and absence of flat flavour.

Oils:

For selection of good quality fats and oils, one must look for following points:

- Ensure that the fats and oils are clean and free from any solid particles, dirt, dust and bad odour. Criteria for selection of crude oil are presence of the natural characteristic aroma, natural colour, clarity, freedom from admixture with other kinds of oils, freedom from solid particles and flat or rancid odour.
- Do not buy oils/ fats loose from the market, as they might be adulterated. Instead buy oil packaged in tin or poly-jars.

Refined oils have a longer shelf-life than unrefined oils of the same kind.

Packaged food items:

Packaged food items carry date of manufacture or expiry dates to help assure quality. The most commonly used open dates seen on the food products are as under:

- Sell by date: This is the last recommended day of sale. The date allows for home storage and use.
- Use by date: This tells how long the product will retain top quality after one buys it.
- Expiration date: This is the last day the product should be used or eaten.
- Pack Date: Canned or packaged foods may have pack dates, which tells when the product was processed. This does not tell how long the food will be good.
- Packages of food that are not torn or broken should be bought.
- Canned goods should be free of dents, cracks and bulging lids.

Refrigerated food should feel cold and frozen food should be frozen solid.

UNIT 3

PRIMARY PROCESSING, SECONDARY PROCESSING – STORAGE CHANGES IN GRAINS

All food begins its journey on a farm. This is known as the **agricultural sector.**

Food is then transported to a factory to go through primary and secondary processing. Food may then be stored here for some time before it is required in the retail sector.

From storage, food enters the **distribution sector**. This is where it is transported to the shops to be sold.

The **retail sector** is where food is sold to the consumer. The retail sector does not only include large supermarkets, but also small corner shops and local farmers' markets.

Food processing and production

Food processing refers to the stages raw ingredients go through in order to become something we can eat.

Food production refers to the three-part production of food – input, process and output.

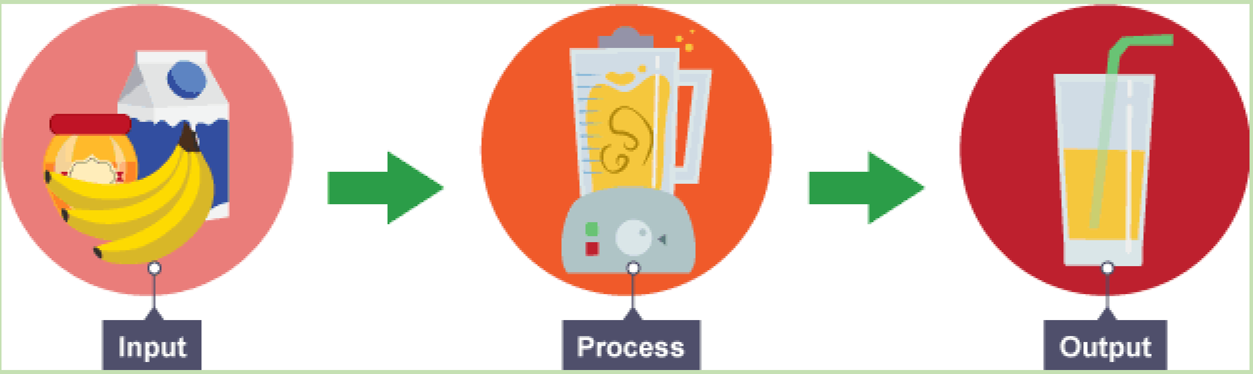
Why do we process food?

Food processing must happen for a number of reasons, these include:

- making food safe to eat by killing harmful bacteria
- making food look and taste its best by adding colour after processing
- making foods become available that are out of season, like frozen raspberries and strawberries
- making foods easier to prepare, this is important for people who live busy lifestyles
- making foods have a longer shelf life by adding preservatives

What is food production?

The process of making a smoothie is a good example of food production – there is the **input** of ingredients followed by the **process** of blending them to create the final **output**.



Primary and secondary processing of wheat

Primary processing is the conversion of raw materials into food commodities – for example, milling wheat into flour. Secondary processing is when the primary product is changed to another product – for example, turning wheat flour into bread.

Why process food?

- Ensures food is safe to eat
- Makes food available all year round regardless of season
- Extends the shelf life of many foods
- Increases the convenience for consumers by reducing preparation time
- Makes some foods edible, for example, making oven fried chips from potatoes
- Makes some food palatable and more enjoyable to eat, for example, soy beans.
- Can add extra nutritional benefits (e.g functional foods) or meet specific nutritional needs (e.g gluten free)

Primary Processing

Primary processing involves a range of processes to make food safe to eat so that it can be consumed individually or used in the manufacture of other food products. The physical form changes very little.

- Harvesting
- Picking
- Washing
- Grading
- Sorting
- Milling
- Packaging
- Weighing

Secondary Processing

Secondary processing is the methods used to turn primary processed foods into other food products either on their own or mixed with other ingredients. The physical form can change quite significantly as a result of secondary processing.

- Juicing
- Peeling
- Stewing
- Dicing
- Mixing
- Canning
- Kneading
- Cooking
- Drying

Both cereals and pulses are nutritionally important, since both together constitute the staple foods for the population. They are also a relatively cheap source of energy, protein and important vitamins and minerals. All food grains need some kind of processing for bringing them to a palatable state and for their efficient and economic utilization. This is due to the fact that grains contain an outer protective cover of fibrous husk/bran layer.

Cereal grains like rice and maize also contain oil rich bran/germ, which are of high economic value, but are undesirable for the purpose of storage. Separation of these parts from the grains is generally referred to as primary processing and is a prerequisite to make them more palatable and safe for storage. The process of preparing certain products like flour, semolina, flakes and popped grains is referred to as secondary processing. Tertiary processing further processes these to provide variety in product making and to meet the growing demands for ready-to-eat or ready-to- use products.

Cereals

Cereals or grains are the seeds of grasses and include the many species of wheat, rice, maize or corn, jowar, barley, ragi, bajra, rye and oats. Cereals account for the largest share, about one-fifth of the consumption expenditure in India. They are mainly consumed in the form of products obtained from primary processing, such as rice from paddy and atta or flour from wheat. Rice, wheat, maize and sorghum are the four major cereals, which are grown and consumed in the country. As per FAO figures for the year 2003, India produces around 102 million MT of rice against world's production of 590 million MT.

The ease with which the grains can be produced and stored, together with the relatively low cost and nutritional contribution has resulted in the widespread use of cereal foods.

Processing of Cereals

Owing to the low moisture content, cereals and pulses are relatively stable during storage; and processing is not so much for preservation. However, processing is of primary importance for bringing them to a palatable state, adding a variety to the diet and inimproving their nutritive value. They are generally milled to remove the outer husk and the resulting product is consumed after cooking and is used in various food preparations.

Cereal processing goes through three stages:

(a) **Harvesting:** It includes threshing, winnowing and preparation for storage of the cereal grain.

(b) **Primary processing**: It involves further treatment of the grain such as cleaning, dehulling (decorticating), pounding and milling; and

(c) **Secondary processing**: It involves transforming the primary processed material into food, i.e., cooking, blending, baking or fermenting and roasting, which makes the grain suitable for human consumption.

The total post-harvest system of cereal processing is given in the following flow chart:

Harvesting
↓
Pre-drying in field
↓
Threshing
↓
Winnowing
↓
Drying
↓
Storage
(Sacks, bags, bulk)
↓
Primary Processing
(Cleaning, grading, hulling, pounding, milling)
↓
Secondary Processing
(Cooking, blending, fermentation)
↓
Packaging & Marketing

(a) Let us now take a look at the major steps involved in the **post-harvest system of cereals.**

(i) Threshing: The process of threshing separates the kernels from the stalks or panicles on which they grow. Threshing may take place in the field, or at the homestead or village; it may be carried out manually with the aid of animals or with machinery. A simple method consists of beating the cereal heads against a wall or the ground; animals or humans can also trample the panicles on a hard surface or animals can draw a machine or sledge over the grain. Maize grains must be separated from the cob after the husk has been removed.

(ii) Grading: Grading consists of separating the sound kernels from chaff and impurities, and may be achieved by sieving or winnowing.

(iii) Sieving: Impurities are separated on the basis of their differences in size from the kernels. Hand sieves are usually used singly. The simpler machines will have two sieves: one with oversized holes (which retain large impurities and let the grain kernel pass through) and the other one with undersized holes (which retain the kernels but allow smaller impurities to pass through).

(iv) Winnowing: In this process, the impurities are separated on the principle that their density differs from that of the grain kernels. The operation depends on air movement to remove the lighter fractions. The simplest method is to drop a basket of kernels and impurities in a thin stream onto a clean surface through a slight natural breeze. This is a slow and laborious process but it is still widely practiced. Winnowing machines operate on the same principle but a fan creates air movement.

(b) Primary processing of wheat: Wheat is consumed mostly in the form of flour obtained by milling the grain. Wheat can be broadly classified into three groups from the milling and baking point of view: (a) Hard wheat, (b) Durum wheat, and (c) Soft wheat. Flour made from hard wheat is used for bread-making, while flour from soft wheat is used for biscuits, cakes and breakfast foods. Semolina is prepared from hard wheat and durum wheat.

Wheat milling: The milling of wheat consists of the separation of bran and germ from endosperm and reduction of endosperm to fine flour. There are three distinct methods of milling wheat: stone milling, roller milling, and fragmentation milling. Irrespective of the method of milling, all wheat grains will go through two main stages before being milled:

1. Cleaning: Cleaning of the grain is the main step before milling. The objective is to remove grains of other cereals, seeds from a variety of field weeds, straw, dust and mud from fields, stones, live and dead insects, small rodents and their excreta and small pieces of metal.

The processing stage of cleaning is usually broken down into four separate operations:

(a) Screening: The grain is passed through several sieving operations to remove items both larger and smaller than it. It is then passed along a conveyor belt, where any pieces of metal are removed magnetically and dust, rodent hairs etc. are removed by the use of current air.

(b) Sorting: At this stage, all non-wheat grains such as barley and oats are removed by passing through a range of separators which remove all foreign grains by virtue of their size.

(c) Scrubbing: The grain is passed through scanners which remove any mud or dirt and the beard and bee wing from each grain (the bee wing is the epidermis or outer layer of the bran coatings).

(d) Washing: This operation cleans the grains by removing any fine dust and hairs, and also any stones, which have not been removed previously. After washing the grain is centrifuged to remove excess surface water.

2. Conditioning: The grain is conditioned to desired moisture content by the addition of water. The purpose of conditioning is to make the bran and germ pliable, thus preventing them from getting powdered. This may be done by moistening the grain and allowed for 24-72 hrs, depending on the air temperature. The cleaned and conditioned wheat is then ready to be milled by one of the following methods:

(i) Stone-milling: The traditional procedure for milling wheat in India has been the stone grinding (chakki) to obtain whole meal flour (atta). In the stone mill, two circular stones are used, each with its surface corrugated radially, with the distance between the stones being smaller towards the outer edge of the stones. In the operation, the cleaned and conditioned grain enters from the above into an aperture in the center of the top stone.

The bottom stone is stationery at all times whilst the top one revolves, grinding the grain more finely as it is pushed to the outside of the stones. The resulting flour is then sieved before being bagged. The method results in 90-95% extraction rate flour, which retains almost all the nutrients of the grain, while simultaneously eliminating the part of the grain which is most indigestible, like cellulose and phytic acid, which binds and carries away the minerals.

(ii) Roller-milling: The roller-milling is a much more complete method than stone milling and involves a large amount of specialized equipment. It is concerned with the milling of white flour, where bran and germ are separated from endosperm and flour of any extraction rate can be produced. The process can be broken down into two clear stages:

• *Breaking*: The cleaned and conditioned grain is passed through a series of break rolls. These are the grooved rollers, which operate in pairs, rotating in the opposite direction to each other, the top one rotating two and a half times faster than the lower roller. It is usual for the mill to have five sets of break rolls, with each set being more finely set than the previous set of break rolls. Each of the above are passed through purifiers, where by means of air currents any minute particles of bran are removed to ensure purity of the white flour end-product.

• *Reduction*: The purpose of this stage is to reduce the endosperm to fine flour and to extract the germ. The reduction stage is less complicated than the breaking stage. It consists of a series of reduction rollers, which are smooth and each pair is set more finely than the previous set. After passing through each set of reduction roller, the product is sieved; the coarse particles go to the next set of rollers for finer reduction. The process is repeated until all the semolina, which was fed into the reduction rollers, is reduced to fine white flour, germ and a small amount of branny by-product. The germ is extracted early in the reduction stage, where it is easily sifted off because being of a tough and oily nature, it is flattened on the rolls with little fragmentation taking place.

(iii) Fragmentation-milling (Air classification): This is a relatively new method of milling, by which it is possible to control the protein quality and quantity in the production of a particular flour. This is a refinement of roller-milling in that after producing the white flour, it is then processed a further step and is separated by means of air classification into particles of three broad ranges, lesser the size, higher the protein content.

Primary processing of Rice

Rice is the staple food for the majority of the world's population and is cooked in boiling water and eaten mostly with cooked pulses, vegetables, fish or meat. It is also used in many food preparations like idli and dosa. Rice with the husk is called paddy. Primary processing of rice consists of cleaning, grading, dehusking (shelling) and milling (polishing). Dehusking and polishing are traditionally accomplished by hand pounding, using pestle and mortar. In modern rice milling, the two main steps involved are dehusking and polishing.

(i) Cleaning and grading: The paddy as received will contain foreign matter such as stones, clay particles, straw, chaff and dirt. These have to be separated in a paddy cleaner.

(ii) Dehusking (shelling): After cleaning, the outer husk is first removed by shelling process exposing the grain covered by a brown bran layer. It is sold in this condition as brown rice. The shelling is carried out normally using two different types of shellers:

(a) Disc sheller: It consists of two discs. The inside surface of the discs is covered with a mixture of emery and hard cement. The clearance between the discs is adjusted close to the length of the paddy grain to be shelled. One plate is stationary, while the second plate revolves. The husk is removed by aspiration.

(b) Roller type Sheller: It consists of two horizontally set rubber rollers rotating in opposite directions, the differential rotation between the two being kept at about 200 per min. Dehusking is effected by the grain hitting the rotating rollers. The resulting brown rice contains the pericarp and germ almost intact. The breakage of rice is minimum with this machine.

(iii) Rice milling (polishing): The brown rice obtained by shelling can be milled (polished) further in a stage known as "pearling" using either a cone-type polisher or a horizontal-type polisher to remove the coarse outer layers of bran and germ, leaving a white grain. Sometimes, the polished rice is further treated with mineral substances such as talc or sugar to give the grain a bright shining surface.

Subsequently, a simple machine like huller came into existence. Hullers achieve both dehusking and polishing in one step. It is estimated that there are over 1, 30,000 hullers in operation throughout the country. They are largely located in the rural areas. More than 30% of paddy produced is processed in hullers.

(iv) Parboiled rice: Parboiling is an ancient process of India. More than 50% of paddy produced in the country is parboiled. Parboiling means partial boiling and cooking of rice in a limited water environment. For this reason, prior to milling, the paddy is fully soaked in water and then the drained paddy is cooked by steaming or by dry heat. The process gelatinizes the starch in the grain aiding the retention of much of the natural vitamin and mineral content. Surprisingly, parboiled rice takes longer to cook, but has the advantage of taking up more water during cooking and therefore increasing the yield.

(v) By-products of rice: The important by-products obtained in rice milling are rice bran oil, bran or polishing (good source of protein and fat), husk (fuel, insulating material, paper making, production of furfural).

(vi) Rice products: Of the 100 million tons of paddy, about 10% is converted to various products like flaked rice (Aval, Chewda or beaten rice), expanded rice (Puri, Murmura) and popped rice (Aralu, Kheel). The other rice products are instant rice (quick cooking rice), rice flour, rice starch etc.

Processing of minor cereals

Maize, jowar, bajra, ragi and other small millets are important minor cereals of our country. They are also termed as coarse grains. They are widely consumed without much refinement by the poorer sections of the population, particularly in the rural areas.

Judicious refining of these grains can upgrade their appearance and eating quality by removal of the unpalatable rough bran layers without affecting their nutritive quality.

Traditional milling of these grains is done by pounding in a mortar and pestle to remove the outer bran. Dry and slightly wet (soaked in water to soften the bran) and tempered grains are used. After pounding, the bran is removed by winnowing and the endosperm is ground in the same unit or small mechanical hammer/plate mills. Pounding is a very laborious and time-consuming operation and also the quality of the product is often not very good because of high moisture content of the flour and mixing of ground bran. In the mid-sixties, it has been observed that when 3-5% water was mixed with the grains and tempered for 5-15 minutes, the outer bran layers were sufficiently toughened and could be abraded off (without powdering) in simple abrasive rice polishers (pearlers) without affecting the inner grain portion, which remained hard. This pearling technique has been applied successfully to jowar, bajra, varagu and wheat. The pearled grains find wide use for traditional preparations like roti, bhakri, bhath etc.

SECONDARY PROCESSING

Secondary processing of cereals (or 'adding value' to cereals) is the utilisation of the primary products (whole grains, flakes or flour) to make more interesting products and add variety to the diet. Secondary processing of cereals includes the following processes: fermentation, baking, puffing, flaking, frying and extrusion.

Puffing. Puffed grains are often used as breakfast cereals or as snack food. During puffing, grains are exposed to a very high steam pressure which causes the grain to burst open. The puffed grains can be further processed by toasting, coating or mixing with other ingredients.Flaking. Flaked cereals are partially cooked and can be used as quick-cooking or ready to eat foods. The grains are softened by partially cooking in steam. They are then pressed or rolled into flakes which are dried. The flakes are eaten crisp and should have a moisture content of below 7%.

Fermentation. Doughs made from cereal flour can be fermented to make a range of products.

Baking. Doughs and batters made from cereal flours are baked to produce a range of goods.

Extrusion. Extrusion involves heating and forcing food (usually a dough) through a small hole to make strands or other shapes. The extruded shapes then undergo further processing such as frying, boiling or drying. Extruded products include pastas, noodles, snack foods and breakfast cereals.

Projects and small businesses may involve only one or several of the activities in the total chain, from the growing of crops through to the production of edible products. Some small businesses are set up to clean and package wholegrains. These businesses can be successful as there is very little need for equipment. However, as with all businesses, there must be a clear demand for the product.

STORAGE CHANGES IN GRAINS-

Destructive agents in storage

Storage of agricultural products is essential to avoid Minimization of losses, during storage of grains, due to rats, insects, diseases etc. it is essential to maintain good quality. Insect pests form one of the most important factors responsible for losses in agricultural production at various stages. Living organisms and the environment interact to bring about spoilage of stored products. Living organisms may be plant, insects, pests, man, animal, bacteria, fungi etc.

The number of insect species may be nearly one million, but only one per cent of the species may perhaps be harmful to man by consuming and contaminating the food. Insects have the capacity to adapt to any environmental condition. Several species can live in stored grain having very low moisture content. They enter into any hard-to-get-to places because of their small size. Some insects can live in darkness while some other live in light.

It is estimated that 5 to 10% of the world food production is damaged by insects during storage. The estimated losses due to insects in India, have been estimated to be around 3% of the country's production. Insects feed on the germ and endosperm causing loss in weight as well as nutrients. Besides, they cause contamination with their excreta and dead bodies. The damages can be grouped into,

(1) direct damages, and (2) indirect damages.

Direct damages

(i) Some insects consume germ, some endosperm and the others eat away both. This results in loss of weight, loss or conversion of nutrients, loss of germination power, loss in gradation, and consequently fall in market value.

(ii) The contamination may be with the dead bodies, cast skin, excreta, obnoxious Odour and/or webbings.

(iii) Structures and containers 'may also be damaged by causing tunnelling in wooden parts resulting in the weakening of the structure/container.

Indirect damages

(i) It may create heating and migration of moisture.

(ii) It may create distribution of parasites to man. Certain tape worms use stored grain insects as intermediate hosts.

(iii) It causes customer's resistance/repulsion which may lower the prestige.

AGENTS CAUSING GRAIN SPOILAGE

The major physical, chemical & biological factors affecting the storage of bio-materials include:

- Micro organisms
- Insects, mite and pests
- Rodents
- Environmental factors

1. **Micro organisms**
    a. Major micro organism associated with storage includes:
    b. Fungi
    c. Bacterial
    d. Yeast
    e. The activities of micro organism result in:
    f. Color degradation
    g. Off flavor
    h. Moisture upgrading, wet spot & moldiness
    i. Loss of viability, etc
2. **Insects, Mite and Pests**
    a. The activity of Insects, Mite and Pests affects the storage by following ways
    b. Insects, mites and pests attack both the stored material and wooden components of the storage structure
    c. Weevils are the commonest insects in grains. They attack seeds and bore through them, and lay eggs in the seeds and storage structures
    d. They reduce seed weight, quality, nutritional value and viability

3. **Rodents**
    a. The Rodents affect the storage by following ways
    b. Rodents are mammals that parasite on stored materials and attack storage structures
    c. They eat germs of grains and waste the remaining parts
    d. They are vectors. They also contaminate stored materials with their faeces, urine and carcasses
4. **Environmental Factors**
    a. The environmental factors that mostly associated with stored products include:
    b. Temperature
    c. Relative humidity
    d. Equilibrium moisture content

Sources of infestation

There are mainly five sources of infestation namely, the field itself, infested gunnies, Infested transport, infested godown and infested stocks.

1. **Field**
   Insects may attack the crop in the field itself. Grains affected by these insects when brought to the storage centres. will be subjected to their continuous attack. The infestation may be visible or invisible. Their stocks should, therefore, be fumigated immediately on receipt.
2. **Infested gunnies**
   Even if sound and new gunnies are used for packing the newly harvested grains, the insects hiding in the seams of the gunnies will attack the freshly harvested stocks. The gunnies should be fumigated before packing the freshly harvested grains:
3. **Infested transport**
   The transport used for carrying the newly harvested stocks should invariably be sprayed with DDVP or malathion. If the transport like bullock cart or tractor trolley has been used for carrying infested stocks on the " previous occasion, the left over insects may attack the stocks now loaded into them.
4. **Infested godowns**
   Even if the stocks are moved to a freshly taken over godown, it is not free from trouble. The insects present in the cracks and crevices of the wall or that hibernate in the structures, may emerge out and attack the grains. Hence the cracks and crevices should be plugged and empty godowns should be thoroughly cleaned and fumigated.
5. **Infested stocks**
   In case sound stocks are brought to a godown where infested stocks are in storage, cross infestation takes place.

Changes during storage

1. Respiration

In a natural atmosphere gaseous exchange will occur in a stored cereal crop. This is due to respiration and it involves depletion in atmospheric oxygen and an increase in carbon dioxide with the liberation of water, and energy (as heat). Respiration rates measured normally include a major contribution from microorganisms that are invariably present at harvest; nevertheless, even ripe dry grain, suitable for storing, contains living tissues in which respiration takes place, albeit at a very slow rate. The aleurone and embryo are the tissues involved and like other organism present, their rate of respiration increases with moisture content and temperature.

Respiration is a means of releasing energy from stored nutrients (mainly carbohydrates) and a consequence of long storage is a loss of weight. Respiration can be reduced by artificially depicting the oxygen in the atmosphere.

2. Germination

Germination of grain is an essential and natural phase in the development of a new generation of plant. It involves the initiation of growth of the embryo into a plantlet, Roots develop from the redicle and leaves and stern develop from the plumule. Hydrolytic enzymes are released into the starchy endosperm, and these catalyze the breakdown of stored nutrients into soluble form available to the developing plant.

Deterioration results from loss of weight due to enzyme activity and a loss of quality resulting from excessive enzyme activity in the products of processing.

3. Microbial infestation

Fungal spores and mycelia, bacteria and yeasts are present on the surfaces of all cereal crops. During storage they respire and given adequate moisture temperature and oxygen, they grow and reproduce, causing serious deterioration in grains.

Field fungi thrive in a relative humidity (RH) of 90-100% while storage fungi require 70-90% RH.

As with other spoilage agents dependent upon minimum moisture content, fungi may be a problem even when the overall moisture in the store is below the safe level. This can result from air movements leading to moisture migration. Unless temperature gradients are extreme the exchanges occur in the vapour phase; nevertheless, variations in moisture content up to 10% within a store are possible.

4. Insects and Arachnids

Insects that infest stored grains belong to the beetle or moth orders; they include those capable of attacking whole grain (primary pest) and these that feed on grain already attacked by other pats (secondary). All arachnid pests belong the order Acarina (mites) and include primary and secondary pests. Most of the common insects and miles are cosmopolitan species found throughout the world where grain is harvested and stored. Insects and mites can be easily distinguished as arachnids have eight legs and insects, in their most conspicuous form have six.

Arachnids

Common name	**Family**
Grain (or flour) mite 	Acaridae
Rust red grain beetle 	
Lesser grain borer 	
Grain weevil 	
Rice weevil 	

Maize weevil 	
Angoumois grain moth 	

Alphabetical list of Primary Insects and Arachnid pests

Those insects listed in the table are considered major pests. They are particularly well adapted to life in the grain bin and are responsible for most of the insect damage to stored grain and cereal products. Minor pats occur mainly in stores in which grain has started to deteriorate due to other causes while incidental pests include those that arrive by chance and need not even be able to feed on grains. Among the major primary pests five species develop inside grains weevils (grain, rice and maize) by egg inside while lesser grain borers and Angoumois grain moths deposit eggs outside but their newly hatched larvae promptly tunnel into grains. The presence of the insect and the damage it causes may not be evident from outside even though only a hollow bran coat may remain. Detection by means of soft X-rays is possible.

Damages by insects and mites

A serious grain loss due to consumption of grain by insects and mites occurs only after prolonged storage under suitably warm conditions. They are most serious in hot climates. Other problems caused by insect include creation of hotspots around insect populations where metabolic activity leads to local heating. Moisture movements and condensation in cooler areas results in caking and encourages fungal infestation.

Introduction of insects and mites from wheat stores to flour mills can cause serious deterioration in the products. Mite excreta taint Flour with a minty smell and hairs from the animals' bodies can cause 'Skin and lung disorders in workers handling infected flour. Silk from the larvae of the Mediterranean flour moth webs together causing agglomeration (heaping together) of grains and blockages in handling and processing equipment. In tropical countries termites can weaken the structure of a store, leading its collapse.

Vertebrate pests

The principal vertebrate pests to cereal stores are rodents and birds. In many countries the three main rodent species involved are:

- Rattus norvegicus : the Norway common or brown rate.
- Rattus rattus : the roofs, ships and black rat;
- Mus musculus : the house mouse

Apart from consuming germs, particularly the embryo of maize, rodent causes spoilage through their excretions which contain micro-organisms pathogenic to man. These include salmonellosis murine typhus, rat-bite fever and wail's disease. Rodents also damage stores structural elements, containers, water pipes and electric cables.

In well-managed stores access by rodents is denied and good housekeeping practice such as removal of grain spoilages, maintenance of uncluttered surroundings and regular inspections, prevent problems. The same is true of birds. These are serious pests only when access is easy, as for example in hot countries where grain may be left to dry in the sun. Damage to drains and blockage of pipes by nests can give rise to secondary storage problems through promoting local dampness in some stores.

Control of Pests in storage

Deterioration in store is less likely if care is taken to ensure that the grain is in a suitable condition for storing, Criteria for the latter include suitably low moisture content, a low mould count and freedom from insects.

Wheat containing live insects can be sterilized by passage through an entoleter, run at about 1450 rev/min. Hollow grains and insects may be broken up and can be removed by subsequent aspiration.

The store itself should provide protection from weather (particularly wet) and intrusion by insects and rodents.

High temperatures are undesirable and variation should be reduced to a minimum as this can lead to local accumulation of moisture.

All spoilage agents depend upon respiration and hence a depletion of oxygen inhibits their proliferation and activity. To achieve this, it is necessary to provide a seal around the grain and a minimal headspace. In a sealed store oxygen depletion can be achieved by natural or artificial fans, Natural depletion results from respiration which in most organisms consumes oxygen and produces carbon dioxide. Artificial atmosphere control comes about by flushing of interstitial and head spaces with a gas other than oxygen. Usually nitrogen or CO_2 as these are relatively inexpensive. Complete removal of oxygen is not possible.

Seated conditions are unusual and prevention of spoilage in many cases depends upon careful maintaining of the stored grains' condition, and prophylactics treatments with chemicals. Fortunately, nearly all threats to grain quality cause temperature rises and monitoring of temperature, through incorporation of thermocouples, can reveal a great deal about condition.

Forced ventilation can reduce temperatures but it may be necessary to remove the cause by use of chemical treatments. Such treatments are relevant primarily when the problem is caused by insects. Because of the possible persistence of pesticides on cereals, their use in stores is increasingly becoming regarded as a last resort. In most countries strict codes of practice apply to their uses.

Pesticides used to control insects, during storage of cereal grains, are of two types. Those that are designed as a respiratory poison and are hence applied as gas or volatile liquid, are described as fumigants.

Those designed to kill by contact or ingestion arc described as insecticides. They may be applied in liquid or solid form.

Of the gaseous fumigants, methyl bromide and phosphine (PH) are the main examples. Examples of 'liquid' fumigant are mixture of 1,1 dichloroethane and tetrachloromethane although the most effective fumigant is methyl bromide, this gas does not penetrate bulk grain well and the use of a carrier gas such as tetrachloromethane is an alternative to the fan-assisted circulatory system required if methyl bromide is used alone. Few stores have the necessary fans.

The period of treatment required depends upon the susceptibility of the species of insects present to the fumigant. For example, three-day exposure to phosphine may eliminate the saw-toothed grain beetle but six days at low temperature may be needed to kill the grain weevil. A liquid-' fumigant penetrates bulks well. The proportions need to be adjusted to suit the depth of the grain stored. Up to three metres deep a 3: 1 mixture of 1, 2 dichloroerhane: tetrachlcromethane is suitable but for penetration to a depth of 50 m equua1 proportions are needed. Fumigation requires the stores be sealed to prevent escape of the toxic fumes.

UNIT 4

FOOD SPOILAGE – CAUSES AND FACTORS AFFECTING CHEMICAL NATURE

Introduction

Healthy tissues inside foods and foods in their natural form resist infection and they do not harbour microorganisms. On the other hand, spoilage of highly perishable foods is natural. The onset of food spoilage is rather indefinite. It is a gradual process occurring because of poor sanitation, enzymatic or chemical reactions, improper temperature controls, microbial growth or physical abuse starting from the time food is harvested, slaughtered or manufactured till it is consumed. Physical changes, such as bruising or puncturing of tissue and water loss and chemical changes, such as those caused by enzymes; or the effects of microbial growth can make food unappealing.

Foods undergo undesirable changes in the physical and chemical characteristics of food ultimately leading to spoilage of food. In general, food spoilage is a state in which food is deprived of its good or effective qualities. **Spoilage of food refers to the undesirable alterations in foods or the food undergoes some physiological, chemical and biological changes, which renders it inedible or hazardous to eat. In extreme cases, the food becomes totally unpalatable and unfit for human consumption.** Hence, it is essential to process or preserve foods after it is harvested or slaughtered to combat the problem of food spoilage.

Undesirable Changes in Food due to Spoilage

Food deterioration is manifested by the reduction in aroma, flavour, textural and nutritional values of foods. Different types of undesirable changes which occur due to spoilage in food are listed as follows:

Change in colour: The fruits like bananas and apples turn black after storing for a long period of time and reduce the acceptability of food.

Change in smell: Rancid smell of spoiled oils and fats, bitter smell of curd or sour smell of starchy food.

Change in consistency: Splitting of milk, curdling of milk, stickiness and undesirable viscosity in spoiled cooked dal and curries and spoiled cooked vegetables.

Change in texture: Some vegetables like potato, brinjal and carrot undergo too much softening leading to rotting.

Change due to mechanical damage: Mechanical damages such as eggs with broken shells, mechanical spoilage of fruits and vegetables during transportation also constitute food spoilage.

Factors Affecting Food Spoilage - The types of spoilage of a particular food item depend to a great extent on the following:

The composition of food: The composition of food influences its susceptibility to spoilage. For example- presence of proteins and carbohydrates especially sugars are preferred by microorganisms for energy source. Very few utilize fat for energy production.

Structure of the food item: Whole healthy tissues of food from inside are sterile or low in microbial content. Skin, rind or shell on food works as its protective covering from spoilage microorganisms.

Types of microorganisms involved: The types of microorganisms present in food depend on its composition of food.

Conditions of storage of the food: Conditions of storage of food affect the growth of microorganisms. Even if the proper storage of food is done, the food loses its freshness and nutritive value if it is stored for too long.

Classification of Foods by ease of Spoilage -Foods are classified into three groups based on ease of their spoilage.

Relatively stable or non-perishable foods: Foods that do not spoil unless handled carefully. E.g. grains, flour, sugar, pulses etc.

Protectable or semi-perishable foods: Foods those remain unspoiled for a fairly long period if properly handled and stored. E.g. potatoes, apples, onions etc.

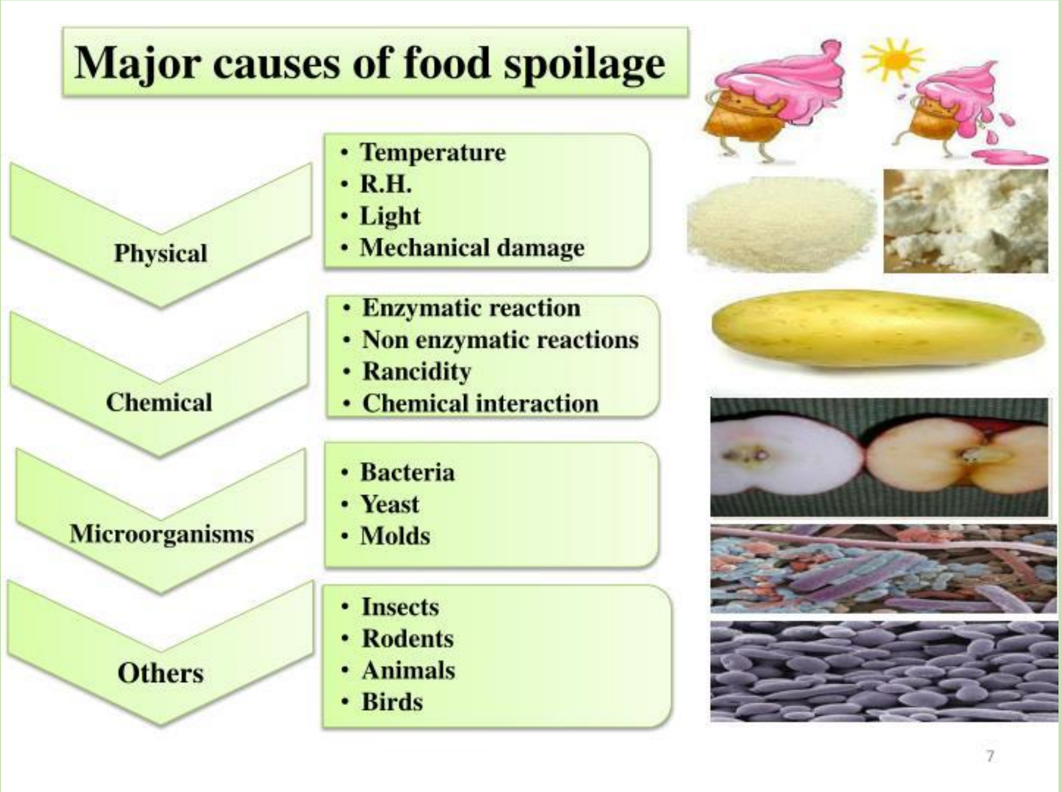
Perishable foods: Foods that spoil readily unless special preservative methods are used. E.g. milk, eggs, meat, fish, poultry, most fruits and vegetables.

Causes of Food Spoilage

There are mainly three types of causes of food spoilage viz. biological, chemical and physical causes. Biological causes comprise of growth and activity of microorganisms such as bacteria, yeast and moulds; activity of food enzymes and damage due to pests, insects and rodents etc. Chemical causes include reaction with oxygen and light and chemical reactions within food constituents. Physical causes consist of temperature and physical abuse.

All of these factors can act together. For example, bacteria, insects, and light, all can be operating concurrently to spoil food in a field or in a warehouse. Similarly, heat, moisture, and air at the same time affect the multiplication and activities of bacteria and chemical activities of food enzymes.

The major types of spoilage that occur in foods are due to microbiological, biochemical, physical and chemical changes. These include:



- Growth and activity of microorganisms such as bacteria, yeast and moulds
- Activities of food enzymes, present in all raw foods, promote chemical reactions within the food affecting especially the food colour, texture and flavour
- Inappropriate holding temperatures (heat and cold) for a given food
- Gain or loss of moisture
- Reaction with oxygen and light causing rancidity and colour changes due to oxidative reactions
- Physical stress or abuse
- Damage due to pests, insects and rodents etc.
- Non-enzymatic reactions in food such as oxidation and mechanical damage

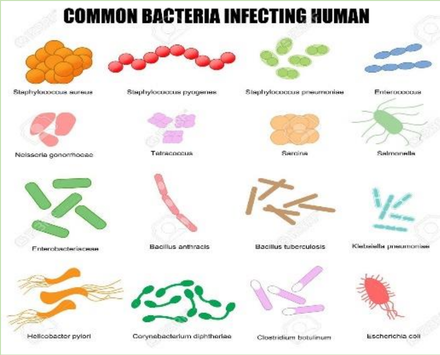
Spoilage due to growth and activity of microorganisms:

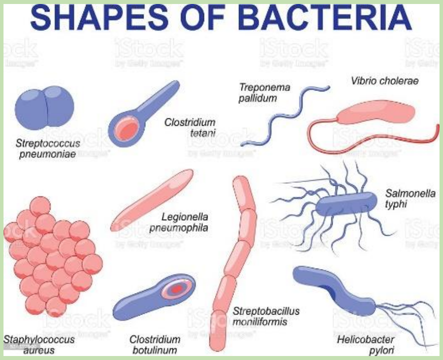
Most significant deteriorative changes occur in foods due to microorganisms present in air, soil, water and on foods. They use our food supply as a source of nutrients for their own growth, which results in deterioration of food and render our food supply unfit for consumption. Microbes spoil any food in many ways viz. by increasing their number; by utilizing nutrients; by producing enzymatic changes; by contributing off-flavours; by breakdown of a product; and by synthesis of new compounds. The three major types of microorganisms which cause food spoilage are bacteria, yeasts and moulds.

- ✓ Bacteria
- ✓ Yeasts
- ✓ Moulds

- ✓ Factors affecting growth of microorganisms
- ✓ Spoilage due to enzymatic activity
- ✓ Factors affecting enzymatic activity
- ✓ Spoilage due to insects, pests and rodents
- ✓ Spoilage due to chemical reactions
- ✓ Spoilage due to physical factor

Bacteria





Bacteria are ubiquitous, minute unicellular microorganisms and cannot be seen with naked eye. The growth of bacteria depends upon specific kind of food, temperature, pH, moisture and oxygen. Bacteria are much more difficult to kill than moulds and yeast and are the most common causes of food spoilage. They are present in two forms viz. vegetative and spore, which are active and resting form, respectively. The vegetative forms of bacteria are easily destroyed at boiling temperature whereas spores require harsh treatments like application of heat (100°C) for a long time (six hours) or at 121°C under 15 psi pressure for 30 min.

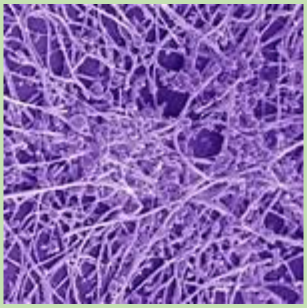
Each kind of bacteria has a definite range of food requirements. Level of moisture in food is important in preventing or allowing the bacterial growth in the food. Bacteria require more moisture than yeasts or moulds. Most bacteria grow best at neutral pH, however, few bacteria also grow in acid or alkaline media. All forms of bacteria are sensitive to acids and can be killed easily in acidic pH at a temperature of boiling water. So foods with high acid content (all fruits, tomatoes, pickles etc.) are processed at 100°C whereas low acid foods such as corn, peas, beans and all vegetables except tomatoes have to be processed at higher temperature (116°C) in a steam pressure to kill bacteria. Moist heat resistant bacteria are present in the soil, hence, preparation and processing of root vegetables require special care. Clostridium botulinum causes spoilage in canned foods.

Bacteria are classified as aerobic, anaerobic and facultative when they require free oxygen for growth, no oxygen and can grow with or without free oxygen, respectively. On the basis of temperature required for growth, bacteria can be grouped into four types viz. mesophiles, obligate thermophiles, facultative thermophiles and psychrophiles requiring temperature below 38°C, 38 to 82°C, below 38 to 82°C and at refrigeration temperatures, respectively.

The most common bacteria causing significant reductions in shelf life of fruits and vegetables is the soft rotting species of the genus Erwinia. Under suitable conditions they produce large quantities of extracellular enzymes which rapidly macerate the tissue which gives unpleasant off-odours.

Some bacteria are also useful particularly in food processing. For example- aerobic bacteria like Acetobacter aceti used in vinegar production and lactic acid bacteria like Lactobacillus plantarum, Pediococcus cerevisiae, Leuconostoc mesenteroides etc. produce lactic acid by fermentation of carbohydrates.

Yeasts



Candida

Penicillium

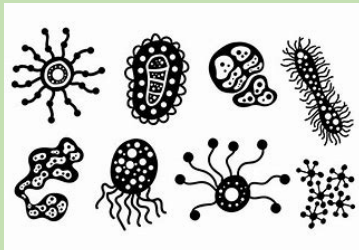
Yeasts are microscopic unicellular fungi, which are non-motile round or elliptical. Yeasts are larger than bacteria in size. Yeasts reproduce by the process of “budding” and therefore known as true yeast. The bud when fully mature, breaks away from the mother cell and becomes independent and repeats the process of multiplication.

Yeasts require less moisture and acidic pH to grow and do not grow in alkaline medium. Yeasts grow under moderate temperature (25-30°C) in sugar solution of low concentration. Most of the yeasts usually do not grow in media containing more than 65 per cent of sugar or 0.5 per cent acetic acid. Heating at 60°C for a few minutes is sufficient to destroy most species of yeasts. Boiling destroys yeast cells and spores effectively.

Some yeasts are very useful in making bread, beer, wine, vinegar and many other fermented products. Yeasts are responsible for fermentation of fruits and fruit products. Yeasts are undesirable when they grow on fruits, juices, squashes, sherbet, honey etc. and spoil the appearance, taste, texture and wholesomeness of fruits and fruit products. During active fermentation, yeast can be recognized by formation of bubbles of carbon dioxide gas on the surface of the product. Some of yeasts which grow on fruits are Saccharomyces, Candida etc. Saccharomyces generally spoils low sugar products whereas Candida is responsible for spoilage of high acid foods, salty foods and butter etc.

Some yeasts which are like true yeast but do not form spores are known as pseudo-yeasts. This type of yeast is not suitable for fermentation as they produce off-flavours and cloudiness.

Moulds



Moulds are multicellular filamentous fungi. They grow on foods with their fuzzy or cottony appearance, sometimes coloured. Moulds are larger and more complex in structure than bacteria or yeast. Moulds are made up of mycelium and spores. They grow in a network of hair like fibres called mycelia and send up fruiting bodies that yield spores. Some of common moulds are Aspergillus, Penicillium, Rhizopus and Heliminthosporium. Usually a moldy or mildewed food is considered unfit to eat.

They thrive best in closed, damp and dark situation and require adequate supply of warmth, moisture and air for growth. They are strictly aerobic in nature and require less available moisture than yeast and bacteria and can grow well at 25-30°C. Moulds prefer sugar containing substances like jam, jelly, preserves and other sweet products. They can grow at wide range of pH (2 to 8.5) but majority grow well at acidic pH. Therefore, they grow nicely on pickles, juices etc. They can grow on many kind of foods especially when temperature, air and humidity are favourable. Their growth can be seen only on the surface of food. Majority of moulds are sensitive to heat and are destroyed at 60°C when heated for 30 minutes. Boiling quickly destroys both moulds and their spores.

They not only consume nutrients present in food thereby lowering the food value but also produce odd by-products, which spoil the flavour, taste and texture of food hence change the quality contents of the entire product. Some moulds produce toxic substances known as mycotoxins. For example, Aspergillus flavus produces aflatoxins in moist groundnuts.

Factors Affecting Growth of Microorganisms

Growth of microbes and their propagation in the food is one of the important factors to food spoilage. They decrease the nutritive value and wholesomeness of food. Hence, the knowledge of the factors that favour or inhibit growth of microorganisms is essential to an understanding of the principles of food spoilage or preservation. The various factors that affect the growth of microbes are given as follows:

Nutrients and other constituents in food:

Nutrients in food, their kinds and proportions, are all important in determining what organism is most likely to microbes like bacteria and moulds. The aerobic degradation does not result into objectionable products, but anaerobic degradation of protein may result into awful odour and is called putrefaction. Smell of hydrogen sulphide (H_2S) and ammonia (NH_3) is common during putrefaction.

Carbohydrates are the most preferred nutrients for microbial growth and are affected primarily by yeast and mouldsgrow. Proteins are degraded by the proteolytic enzymes present in aerobic and anaerobic.

Microbes degrade carbohydrates in food resulting in the production of alcohol, lactic acid, acetic acid, propionic acid, butyric acid etc.

Microbes break down fats in food resulting in the production of fatty acids and glycerol. Fats are mainly digested by moulds and few gram negative bacteria.

Organic acids are mostly present as salts in food. These are oxidized to carbonates by the microbes making the food alkaline.

Acidity:

Foods having pH below 4.5 and above 4.5 are classified as acidic and non-acidic foods, respectively. Acidic foods are mainly spoiled by moulds and yeasts whereas the non-acidic foods are particularly attacked by bacterial spoilage.

Water content:

Microbes require at least 13 per cent free water for their growth and it is best expressed in terms of available water or water activity (aw). The aw of pure water is 1.0 and many bacteria, yeasts and moulds require 0.91, 0.88 and 0.80 aw, respectively. Foods preserved with salt or sugar concentration do not support growth of most microbes. For example, salt concentration of 5-15 per cent inhibits growth of bacteria whereas many moulds and some yeasts can tolerate more than 15 per cent. Sugar concentration of 65 per cent and above is required to inhibit mould growth whereas 50 per cent do not allow bacteria and most yeasts.

Physical and environmental factors:

Temperature of food affects the growth of microbes. Temperature in the range 20-50°C is most suitable for the growth of microbes. Most of the bacterial pathogens of fruits and vegetables will grow between 6 and 35°C. Some fungi (Botrytis cinerea) will survive and even grow at low temperatures, 1°C, on agricultural produce, whereas Botryodiplodia theobromae or Aspergillus niger cause losses in warm regions.

Availability of oxygen:

Anaerobic micro-organisms are mainly involved in the spoilage of air tight canned food under anaerobic conditions. Oxygen is necessary for mould growth.

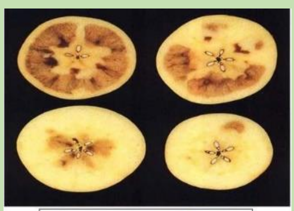
Presence of inhibitory substances:

Inhibitory substances originally present in food, added purposely or accidentally or developed thereby prevent growth of microorganisms.

Biological structure:

The biological structure of food has a protective function against food spoilage. The inner parts of whole, healthy tissues of living plants and animals are either sterile or low in microbial content.

Spoilage due to Enzymatic Activity


Different stages of enzymatic browning

Enzymes are complex chemical substances, which are present in all living organisms and tissues, which control essential metabolic processes. Different biochemical reactions in foods and plants tissues are catalysed by enzymes. Enzymatic spoilage is the greatest cause of food deterioration. They are responsible for certain undesirable or desirable changes in fruits, vegetables and other foods. Examples involving endogenous enzymes include:

- the post-harvest senescence (leading to ripening of fruit) and spoilage of fruit and vegetables;
- oxidation of phenols in plant tissues to orthoquinones by phenolases, peroxidases and polyphenol oxidases (PPO). These orthoquinones rapidly polymerize to form brown pigments known as melanin leading to enzymic browning;
- sugar – starch conversion in plant tissues by amylases;
- post-harvest demethylation of pectic substances in plant tissues (leading to softening of plant tissues during ripening, and firming of plant tissues during processing).

If enzymatic reactions are uncontrolled, the off-odours, and off-colours may develop in foods.

Factors Affecting Enzymatic Activity

Factors responsible for controlling enzymatic activities are temperature, water activity, pH and chemicals which can inhibit or enhance enzyme activity.

- Enzymes can act between 0°C and 60°C but 37°C is optimum temperature.
- Enzymes can be permanently inactivated by heat. It has been seen that for each 10°C rise in temperature, the activity of microorganisms and enzymes increases by at least twice, in the range 0-60°C.
- Above this, heat quickly destroys enzymes and stops living cells from working. All enzymes are inactivated at 80°C.
- Decreased temperatures therefore work by slowing down these changes.

Spoilage Due to Insects, Pests and Rodents



The main categories of foods subject to insects and pest attack are fruits, vegetables, grains and their processed products. Warm humid environment promotes insect growth, although most insects will not breed if the temperature exceeds above 35°C or falls below 10°C. Many insects cannot reproduce satisfactorily unless the moisture content of their food is greater than 11 per cent.

The presence of insects and pests and their excreta in foods may render consumable loss in the nutritional quality, production of off-flavours and acceleration of decay processes due to creation of higher temperatures and moisture levels and release of enzymes.

The products of insect and pest’s activities such as webbing, clumped-together food particles and holes can also reduce the food values.

Rats and mice carry disease-producing microorganisms on their feet and/or in their feces and urine and contaminate the food by their presence.

Spoilage Due to Chemical Reactions

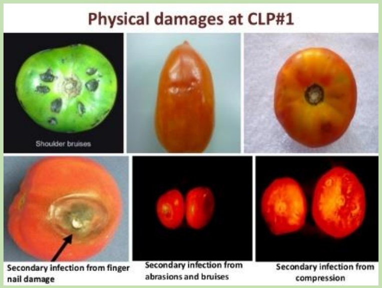
Chemical reactions take place in the presence of atmospheric oxygen and sunlight. Two major chemical changes, which occur during the processing and storage of fruits and vegetables, are lipid oxidation and non-enzymatic browning which deteriorate sensory quality, colour and flavour .


Lipid oxidation is influenced by light, oxygen, high temperature and the presence of iron and copper, and water activity. Control of these factors can significantly reduce the extent of lipid oxidation or rancidity in foods.

Non-enzymatic browning is one of the major causes of deterioration which takes place during frying, cooking, storage of dried and concentrated foods through Maillard, caramelization and ascorbic acid oxidation.

- Maillard reaction occurs due to reactions between reducing sugars and amino acids in the presence of heat and results in formation of black brown insoluble pigments.
- Caramelization of sugars occurs in presence of high heat and low moisture content in the food.
- Oxidation of fatty acids to other chemicals like aldehydes, ketones, alcohols and esters also results in off-flavours.

Spoilage Due to Physical Factors



- ✓ Physical factors such as temperature, moisture and pressure can also cause food spoilage.
- ✓ Physio-chemical reactions are caused by freezing, burning, drying and bruising of fruits and vegetables during storage, handling and transportation, which result in food deteriorations.
- ✓ Food processing or storage causes some deterioration in colour of fruits and vegetables due to the degradation of the chlorophyll resulting dull olive-brown colour.
- ✓ Dehydrated green peas and beans packed in glass containers undergo photo-oxidation and loss of desirable colour occurs.
- ✓ Freezer induced damage observed in frozen foods affects its quality.
- ✓ Anthocyanins, the pigment in fresh and processed foods, form complexes with metals resulting in the change in colour. E.g. Red sour cherries react with tin and form undesirable purple complex.
- ✓ Carotenoid, another colour pigment, degrades by oxidation in the presence oxygen, light and heat.

Effects of Spoilage on Nutritional Quality

Effect of spoilage on nutrient degradation cannot be generalized because of the diverse nature of the various nutrients as well as the chemical heterogeneity within each class of compounds and the complex interactions of the above variables. The major nutritional changes which occur in foods due to microbiological, enzymatic and chemical reactions are listed in below Table.

Type of change	Nutritional quality related changes in food
Microbiological	Growth or presence of toxicogenic and/or infective microorganisms
Enzymatic	1. Hydrolytic reactions catalyzed by lipases, proteases, etc. 2. Lipoxygenase activity
Chemical	1. Oxidative rancidity 2. Non-enzymatic browning 3. Nutrient losses

Foods contaminated with microorganisms may cause food borne illness. Food borne illnesses can be classified as food infection and food intoxication.

Food infection occurs due to growth of pathogenic microorganisms in victim's digestive tract causing diarrhea, vomiting, fever etc. For example- Salmonellosis due to consumption of Salmonella sp. contaminated food.

Food intoxication or poisoning is caused due to ingestion of food containing toxic compounds produced by pathogenic microorganisms in food. E.g. Staphylococcus aureus and Clostridium botulinum causes food poisoning.

Measures for the prevention of food spoilage:

Manipulation of factors controlling the conditions required for microbial growth and enzyme action viz. temperature, moisture, air and pH other than the food itself can help prevent food spoilage.

UNIT 5

PRINCIPLES AND METHODS OF FOOD PRESERVATION - drying and dehydration, use of high temperature, use of salt, use of sugar, use of low temperature, preservative-food material as preservatives, use of chemicals, radiation, combination of above methods-changes in constituents, preservation by concentration, recent methods in preservation

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Introduction

Food preservation is one of the oldest technologies used by the mankind. The perishable foods like fruits, vegetables, milk, meat and fish etc. deteriorate or decay easily, so considerable amounts of such commodities are wasted in various stages of food supply chain unless special methods are applied for their preservation. Preservation of food involves the processes in which, the perishable food materials are given a suitable physical or chemical treatment to prevent their spoilage and to retain their nutritive value for long periods.

Principles of Food Preservation

All food preservation methods are based upon the general principle of preventing or retarding the causes of spoilage caused by microbial decomposition, enzymatic and non-enzymatic reaction, chemical or oxidative reactions and damage from mechanical causes, insects and rodents etc. Food preservation operates according to three principles, namely:

Prevention or delay of microbial decomposition brought out by

1. Keeping out microorganisms or asepsis
2. Removal of microorganisms e.g. washing, filtration etc.
3. Hindering the growth and activity of microorganisms by controlling the conditions required for the growth and activity of microorganisms by use of low temperature, drying, maintenance of anaerobic conditions or chemicals
4. Killing microorganisms by heat or irradiation

Prevention or delay of self-decomposition of foods by

1. Destroying or inactivating food enzymes e.g. blanching, low temperature storage, chemical preservation, drying etc.
2. Preventing or delay of chemical reactions e.g. prevention of oxidation with the use of antioxidants as oxygen speeds up decomposition of food and antioxidants deprives food from oxygen.

Prevention of damage because of external factors such as insects, rodents, dust, odour, fumes, and mechanical, fire, heat or water damage.

Eg. Use of boxes, cartons, and shock absorbing materials, sealed tight, vacuum-packaging etc.

METHODS OF FOOD PRESERVATION

The different preservation methods commonly employed are as discussed below:

- **Asepsis**

Food is a living system and in its natural form it has its own protective mechanisms. When the food is removed from the field or protective skin or peel, it begins to deteriorate. Asepsis is a process of keeping microorganisms out of food. An aseptic environment can be created by

- Proper packaging of the product, which separates the internal environment from the surroundings.
- Maintenance of general cleanliness and sanitary conditions while processing and handling the product from raw material to finished stage can help in preventing the entry of microorganisms into the product.

- **Removal of microorganisms**

It is well known fact that microbes are everywhere. The dust and dirt adhering to the raw material contain microorganisms and by applying various pre-treatment/ cooking methods, number of microorganisms can be reduced considerably. Such steps include:

1. Washing
2. Trimming ingredients
3. Discarding dirt
4. Filtering
5. Centrifugation
6. Sedimentation

- **Maintenance of anaerobic conditions/ packaging**

Packaging food in a vacuum environment, usually in an air-tight bag or bottle results in anaerobic environment. As bacteria need oxygen for survival, the vacuum environment in the package slows down the spoilage by them.

- **Drying -** Drying is one of the oldest and the simplest method of preserving food. It refers to removal of water from the food. Dried foods are preserved because the available moisture level is so low that the microorganisms cannot grow and the enzyme activity is also controlled. Drying can be accomplished by a number of methods viz. sun drying, mechanical/ artificial drying and freeze drying etc.

Dried foods are compact and lightweight; do not require refrigeration and last much longer than the fresh foods. Dried foods should be stored in airtight containers to prevent moisture from rehydrating them and allowing microbial growth.

1. Sun drying

Sun-drying takes heat from sun rays but it is a slow process involving risk of contamination and spoilage. The limitation for sun drying is availability of climate with a hot sun and a dry atmosphere.

2. Mechanical/ artificial drying

Dehydration process usually implies the use of controlled conditions of heating, with the forced circulation of air or artificial drying (mechanical drier) in contrast to sun drying. Using mechanical driers, fruits, fruit leathers, banana chips, tea, coffee, milk, soups, fish, meat, eggs and vegetables can all be dried year-round.

3. Freeze drying

Freeze-drying is a form of dehydration in which the product is first frozen and then water is removed under vacuum as vapour by sublimation (transition from solid to vapor state). The principle behind freeze drying is that under certain conditions of low vapour pressure, water in the form ice evaporates as water vapour directly without turning into liquid phase. The advantage is that the food structure and nutritional properties are better conserved but the equipment and its maintenance is costly.

4. Smoking

Smoking has been used as a method of food preservation from time immemorial. In this method, foods are exposed to smoke by burning some special kinds of wood, which has two main purposes, adding desired flavouring and preserving. Smoke contains chemicals like formaldehyde, which is bactericidal. And also the dehydration occurring due to smoking is responsible for its preservative action. The smoke is obtained by burning wood like oak, maple, walnut and mahogany under low breeze/ wind. Most meat is smoked after curing to aid their preservation. Examples of smoke preserved foods are smoked beef, ham, bacon, fish and meat.

- **Food concentration**

Relatively few liquid foods are preserved by concentration, involving preservative action of reduction in water activity (aw) and development of osmotic pressure, which retard the microbial growth and enzymatic reactions. Concentration of food is usually done for many reasons: reduction in volume and weight; reduction in packaging, storage and transport costs; better microbial stability; and convenience. Examples of food preserved by concentration are tomato paste, fruit juice concentrate, soup and condensed milk. The rate of heating should be controlled to prevent localized burning of the product, particularly when it has become thickened towards the end of boiling.

- **Use of high sugar or salt content**

1. Sugaring

A strong sugar solution (about 68 per cent or more) draws water from the microbial cells and thus, inhibits the growth of microbes. Examples of food preserved by high sugar concentrations are fruits in heavy sugar syrup (preserve or murraba), jams, jellies, marmalades, candies and sweetened condensed milk.

2. Pickling

Pickles are the relishing accompaniments in the Indian meals. Microorganisms do not grow well in acidic solutions. And this is the basis of preserving fruits and vegetables by pickling. Pickling uses the salt combined with the acid, such as acetic acid (vinegar). Some of the fruits and vegetables, which are generally pickled, are raw mangoes, limes, Indian gooseberry (aonla), ginger, turmeric and green chillies.

3. Salting or curing

Salting is being done in case of meat and fish preservation since ancient times. Curing preserves the food by drawing moisture from the meat through osmosis and makes it unavailable for microbial growth and enzyme action. Meat is generally cured with salt or sugar, or a combination of the two. Nitrates and nitrites are also often used to cure meat, which contribute the characteristic pink colour to meat, as well as inhibition of Clostridium botulinum. Dry salting is used in India for the preparation of preserved tamarind, raw mango, Indian gooseberry (aonla), fish and meat etc.

- **Use of organic acids** Organic acids are used in food preservation because acid conditions inhibit growth of many spoilage microorganisms. Bacteria are generally pH sensitive. Organic acids penetrate the bacteria cell wall and disrupt its normal physiology and thus preserve the food. Acetic acid, lactic acid, citric acid and malic acid are widely used for preservation in food products.
- **Fermentation**
  Fermentation involves multiplication of microorganisms and their metabolic activities are also encouraged, in contrast to other preservation methods. In this, microorganisms break down complex organic compounds into simpler substances either in aerobic or anaerobic conditions. The chemicals produced by the microorganisms such as alcohol or acids cause the preservative effect of fermentation by slowing down spoilage factors. The principal chemicals involved are the acids (especially lactic acid) and alcohol. These inhibit the growth of common pathogenic organisms in foods. Examples of food preserved by fermentation are alcoholic products (e.g., beer, fruit wine) and acid products (e.g., vinegar, pickled vegetables), yogurt, cheese etc. This technique is often combined with pasteurization.

Use of low Temperatures

The metabolism of a living tissue is a function of the temperature of the environment. Low temperature is applied to retard chemical and enzymatic reactions in food. In addition, reducing temperature retards or stops growth and activity of microorganisms in the food. Lower the temperature, the slower will be the rate of above natural activities. Cooling thus slows down or stops the spoilage of foods.

Freezing and refrigeration are among the oldest methods of preservation. Mechanical ammonia refrigeration systems invented during 1875 allowed development of commercial refrigerated warehousing and freezing.

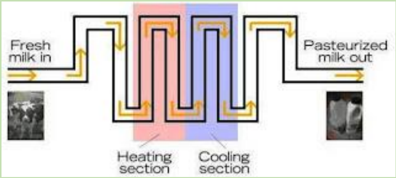
-Low temperatures employed can be:

- Cellar storage temperature (15°C)
  It is usually used for the storage of surplus foods like root crops, potatoes, onions, apples, etc. for limited periods.
- Refrigeration/ chilling temperature (0 to 5°C) Foods kept at this temperature slow down the microbial activities and chemical changes resulting in spoilage. Mechanical refrigerator or cold storage is used for this purpose. Examples of this include meats, poultry, eggs, fish, fresh milk and milk products, fruits, vegetables, etc. which can be preserved for 2-7 days by refrigeration.
- Freezing (-18 to -40°C)
  In freezing, water in food turns into ice and hence, makes the water unavailable for reactions to occur and for microorganisms to grow. Most perishable foods like poultry, meats, fish, ice-creams, peas, vegetables, juice concentrates, etc. can be preserved for several months at this temperature. In vegetables, enzyme action may still produce undesirable effects on flavour and texture during freezing. Heating, like blanching, therefore, must destroy the enzymes before the vegetables are frozen.

Use of High Temperatures

The process of heating was used centuries ago before its action was understood. Food is heated up or cooked. Heat is used to inactivate organisms or enzymes of spoilage significance in the foods. Microorganisms are killed by heat because the application of heat coagulates the food proteins and inactivates the microbial enzymes and thus results in death of microorganisms. The examples include all forms of cooked food, pasteurization, milk sterilized by UHT (ultrahigh temperature), canning etc. One of the most important modern applications of the heat preservation is the pasteurization of milk. Heat treatment of food may be given in different ways:

- Pasteurization (temperature below 100°C)



Pasteurization is a heat treatment involving temperatures below 100°C that kills a part but not all the microorganisms present in food. Milk, for example, is usually heated to 63°C for 30 min or 71°C for 15 seconds or in UHT 138°C for 2-4 seconds. Examples include milk, wine, beer, fruit juices and aerated waters which are routinely pasteurized. The mode of heating can be steam, hot water, dry heat or electric currents. The products are cooled promptly after the heat treatment. Pasteurization is usually supplemented by other methods to prolong shelf-life.

- Boiling (temperature at 100°C)

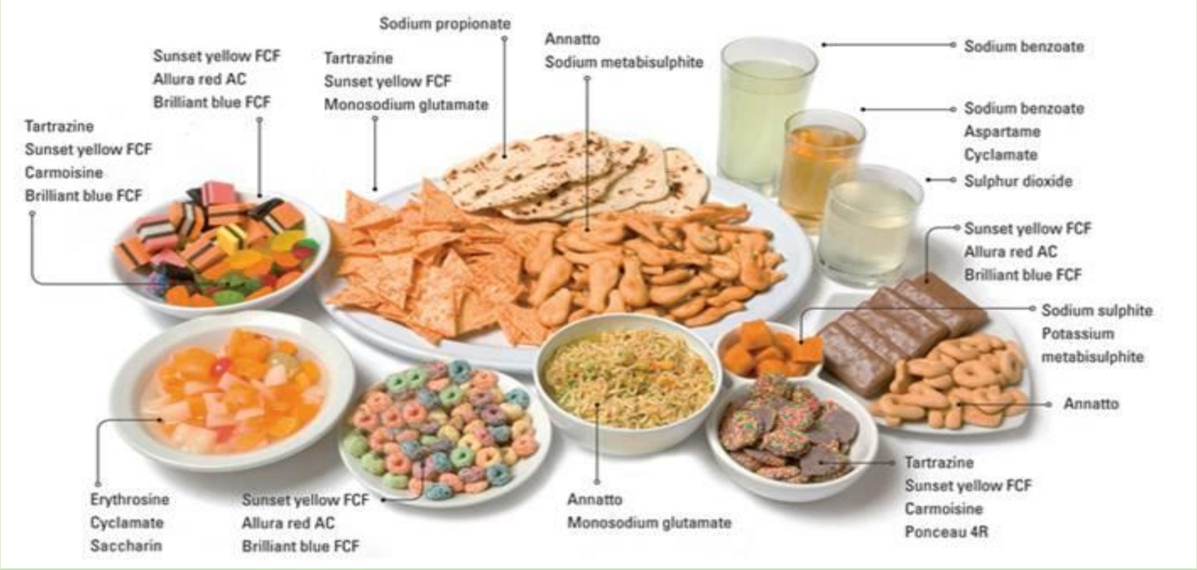
Cooking of rice, vegetables, meat, fish etc. at home is usually done by boiling the food with water and involves a temperature around 100°C.

- Canning (temperature above 100°C)

Canning is the process in which the foods are heated in hermetically sealed (airtight) jars or cans to a temperature that destroys microorganisms and inactivates enzymes that could be a health hazard or cause the food to spoil. The vacuum seal formed after heating and cooling in the process ensures that no microorganism can get into the product. The degree of heat and the length of time of heating vary with the type of food and the kinds of microorganisms that are likely to occur in it. High-acid foods such as fruits and tomatoes can be processed or "canned" in boiling water, while low-acid vegetables and meats must be processed in a pressure canner at 121°C (15 psi pressure). Tin-coated steel cans are most commonly used followed by glass containers. Nowadays, containers made of aluminum and plastics in the form of pouches or rigid containers are also increasingly used. Examples of food preserved by canning are- all kinds of tinned foods, such as soup, meat, beans, cereal grains, legumes, nuts, and other various dried food products such as fruit, coffee, milk, soups, fish, meat and vegetables.

Use of Chemical Preservatives

Chemical preservatives are food additives, which are specifically added to prevent the deterioration or decomposition of a food. Chemicals are used to inhibit the factors causing spoilage. These are also used to complement other food preservation techniques.



Preservation of foods by the chemicals is effected by interfering with the cell membrane of the microorganism, their enzyme activity and genetic mechanism; and by acting as antioxidants. In food preservation, the added chemical preservatives may be grouped into two classes.

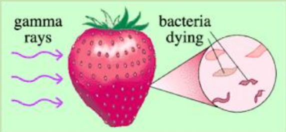
- Class I preservatives:

The first one includes the use of sugar, salt, spices, acetic acid (vinegar) and alcohol, and is referred to as class I preservatives and is considered to be relatively safe to humans.

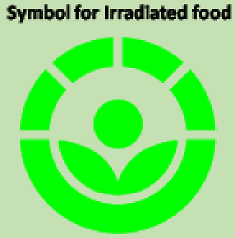
- Class II preservatives:

The second group includes the use of benzoic acid, sulfur dioxide, nitrates and nitrites and a variety of neutralizers, firming agents and bleaching agents and referred to as class II preservatives and is considered to be relatively safe to humans, but within the permissible doses prescribed by the food regulatory bodies of the country because higher concentrations can be a health hazard.

- **Carbonation**
  Carbonation is the process by which carbon dioxide gas is dissolved in food under pressure. The principle behind this is that by eliminating oxygen, carbon dioxide inhibits bacterial growth. E.g. carbonated beverages (soft drinks), therefore, contain a natural preservative.
- **Irradiation**



Food irradiation is low temperature sterilizing technique as in this case, sterilization can be effected at room temperature. Foods are exposed to high-energy rays called gamma rays or by fast-moving electrons, which kill bacteria, fungi and insects. In some cases, irradiation delays fruit ripening. A major advantage of irradiation is that it can be done after the food is packaged and sealed.



It has been used in pasteurizing or sterilizing perishable foods such as meat, fish and fruits and extending their storage lives for long periods. It is also used for sprouting inhibition in onions, potatoes etc. Cobalt-60 or Cesium-137 or electrons producing machines are the principal sources of ionizing radiations used for food irradiation.

- **Combination of Two or More of the Above methods or Hurdle Technology**

Hurdle or barrier concept is based on synergistic action of preservatives and other treatments to preserve food. Hurdle in food is defined as the substance or the processing step or various preservation factors, inhibiting the growth of various microorganisms resulting in the death of microorganisms. Higher the hurdle, greater is the effect. The quantification of various factors in terms of pH, redox-potential, water activity, temperature, preservatives etc. gives the successful level of combination of hurdles, which lead to failure of growth and finally in death of microbes. Hurdle technology helps to give shelf stable food product, with superior quality and with fresh like characters.

FOOD DEHYDRATION AND CONCENTRATION

Drying is the oldest method of food preservation. It is a process derived from nature. Microorganisms need free water in order to grow and multiply. During drying, the water content of the food is reduced to critical level below which microorganisms cannot grow.

Difference Between Drying and Dehydration

Both the terms 'drying' and 'dehydration' mean the removal of water. But the former term is generally used for drying under the influence of non-conventional energy sources like sun and wind whereas dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. The Table 1 illustrates the differences between drying and dehydration.

Table 1. Differences between drying and dehydration processes:

Drying	**Dehydration**
Cheaper	Costlier process.
Colour of dried product is superior when compared to dehydrated product.	Quality is better.
Not practicable unless favourable conditions prevail.	Yield is higher. Microclimate can be controlled. Easy to maintain sanitary conditions. Cooking and keeping quality is better. Requires less floor area and fewer trays

Difference Between Drying/ Dehydration and Concentration

Drying refers to the removal of relatively low amounts of water from a material as vapour by passing hot air while concentration/ evaporation refers to removal of relatively large amount of water as vapour at its boiling temperature. Concentration is not as effective as drying.

Foods are concentrated or dehydrated for the same purpose. Concentration is applicable in case of liquid foods only.

Principle of Preservation by Drying/ Dehydration/ Concentration

The principle behind drying is that sufficient moisture is removed, which is essential for growth of microorganisms and for enzyme activity. Removal of moisture increases the storage life of the product due to reduced water activity. If the moisture content is reduced to 1 to 5 per cent then the product can be stored for more than a year. The processing should be done in such a way that the food value, natural flavour and characteristic cooking quality of the fresh material are retained after drying. A good dried product on reconstitution with water should resemble the original product.

Advantages of Drying

Preservation is the main reason but not the only reason for dehydrating foods. Food may be dehydrated for other reasons also viz. to decrease weight and bulk; to retain size and shape of original food; to produce convenience items. Dehydration/ drying is advantageous for being cheaper than the other methods of preservation with less requirement of equipments. Storage of dried food products does not require special facilities like refrigeration etc. Dried food products are simple to store and pack because of their low volume.

Dehydrated foods however, are less popular because of some undesirable changes in colour, taste and flavour during storage and distribution. Dehydration techniques have been improved to overcome most of these defects.

Factors in control of drying:

Various factors affecting rate of drying in a fresh produce include the following:

- Composition of raw materials: Foods containing high amount of sugar or other solutes dry slowly.
- Size, shape and arrangement of stacking of produce: Greater the surface area greater is the rate of drying.
- Temperature as well as humidity and velocity of air: Greater is the temperature differential between the product and the drying medium faster the product dries. Lower the humidity of environment the faster the drying will be.
- Pressure (atmospheric or under vacuum): Lower the atmospheric pressure the lower the temperature required to evaporate water.
- Heat transfer to surface (conductive, convective and radiative): The fastest method of heat transfer is radiation consecutively followed by convection and conduction.

Types of Drying

Basically, drying can be done by two processes viz. natural drying and mechanical dehydration or artificial drying based on source of energy. Natural drying takes place under the influence of sunlight and wind and is of three types viz. sun, solar and shade drying. In natural drying there is no control over temperature, air flow and humidity whereas in artificial drying, these conditions are well controlled.

Mechanical dehydration or artificial dehydration can be further classified into atmospheric and sub-atmospheric types based on the conditions employed in drying process. On the basis of mode of drying process, drying at atmospheric pressure conditions can be further divided in batch and continuous types. Mechanical drying includes the methods of drying by (1) heated air, (2) direct contact with heated surface e.g. drum drying and (3) application of energy from a radiating microwave or dielectric source.

Commercial dehydrators are generally large in size and various types of dehydrators can be based on circulation of air as (1) Natural and (2) Forced draught. In natural draught, the rising of heated air brings about drying of food in the natural draught method. Examples include kiln, tower and cabinet driers. Forced draught employ currents of heated air that move across the food usually in tunnels. An alternative method is to move the food or a conveyor belt or trays through heated air. Examples include tunnel or belt drier. In forced draught drier, the temperature and humidity can be carefully controlled to get a good dehydrated product but are not in general use because of the cost.

1. Sun drying:

Drying the food product under natural sunny conditions is called as sun drying. No energy is required for the drying process. To practice sun drying of foods, hot days are desirable with minimum temperatures of 35°C with low humidity. Poor quality produce cannot be used for natural drying to achieve good quality dried product. The lower limit of moisture content by this method is approximately 15 per cent. Problems of contamination and intermittent drying are generally encountered with sun drying. It is only possible in areas of low humidity.

Simple equipments are required such as knives, peelers, trays etc. Plastic sheets are also used. Process consists of washing, peeling and preparation of fruit or vegetables. Fruits are generally sulphured whereas vegetables are blanched before drying to prevent enzymatic browning. Fruits are seldom blanched. Fruits are considered to be dry when they show no signs of moisture or stickiness when held firmly in the hand. Vegetables are considered to be dry when they become brittle. At this stage, they should be removed from the dehydrator. The residual moisture in the vegetables should not be more than 6-8 per cent and in fruits 10-20 per cent. Dried fruits can be used as such after soaking, while dried vegetables are usually soaked in water overnight and then cooked.

Table 2. Advantages and disadvantages of sun drying:

Advantages	**Disadvantages**
• No energy is required	• Slow drying process • Time taking • Molding of food may occur due to slow drying • Cannot be carried out in dust, rainy weather

2. Solar drying:

Solar drying uses designed structures to collect and enhance solar radiation. Solar driers generate high air temperature and low humidity which results in faster drying. This drier is faster than sun-drying, and also requires less drying area. But it cannot be used on cloudy days. Generally, three types of solar driers are used, as (1) the absorption or hot box type driers in which the product is directly heated by sun, (2) the indirect or convection driers in which the product is exposed to warm air which is heated by means of a solar absorber or heat exchanger and (3) drier, which is combination of first and second type.

3. Shade drying:

This kind of method is used for foods which lose their colour when exposed to direct sunlight for drying. Generally herbs, green and red chillies, okra and beans etc. are dried under shaded area with good air circulation.

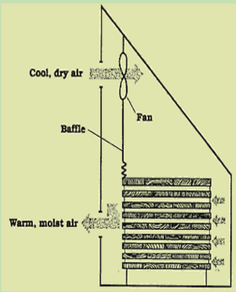
4. A home scale dehydrator or drier:

It consists of a small galvanized box having dimensions of 90x90x60 cm. The lower portion consists of perforated iron tray. The box is fitted on to a wooden frame which is kept about 2-3 feet above ground. At the top there are two slits which can be closed by shutters. About seven trays can be kept in the drier. The material to be heated is kept on trays and heating source can be a gas stove or any other source. The initial temperature of the dehydrator is usually is 43°C which is gradually increased to 60-66°C in the case of vegetables and 66-71°C for fruits. For a home scale drier 100-200 g of sulphur is required for 25 kg fruit. Time required for drying is generally ½ hour to 2 hours.

5. Oven drying:

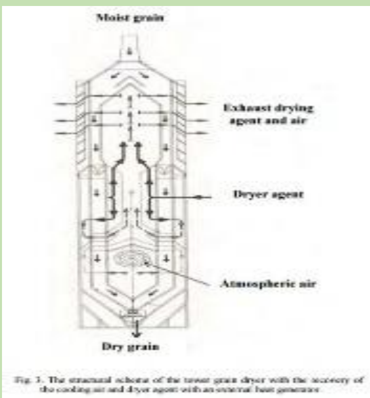
A conventional oven with a thermostatic setting of 60°C is suitable for oven drying of fruits, vegetables, fruit leathers and meats. This is a kind of cabinet drier.

6. Kiln drier:



Also known as kiln evaporator. It consists of two floors. On the top floor, food to be dried is spread and on the lower floor, the furnace is housed. Heat is conveyed by a ventilator. Generally it is used for large pieces of food.

7. Tower drier:

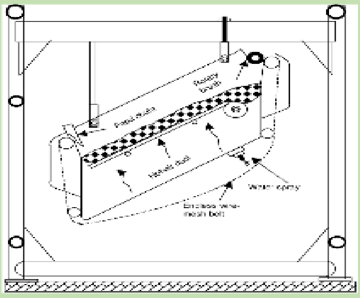


It is also called as stack type drier. This drier consists of a furnace room containing the furnace, heating pipes and cabinet in which fruits are kept in perforated trays. Heated air from the furnace rises through the trays. Heating is through steam coils placed between the trays. The trays are interchanged as drying progresses.

8. Tunnel belt drier:

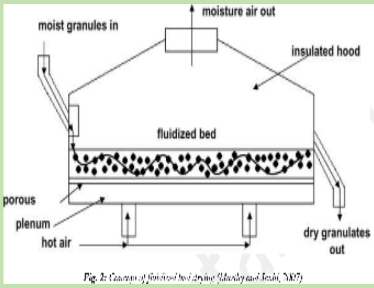
It consists of several parallel sloping and narrow chambers above a furnace room. Trays are passed on a conveyor belt at upper end and removed at the lower end. Air for drying is circulated by a fan. Humidity is controlled by occasionally letting in air. Heating can be direct or by radiation. Indirect heating– heat is passed over material and it is sufficient, but there is risk of overheating. By radiation air is heated over pipes carrying hot gases from furnace. Steam pipes may also be used.

9. Belt-trough drier:



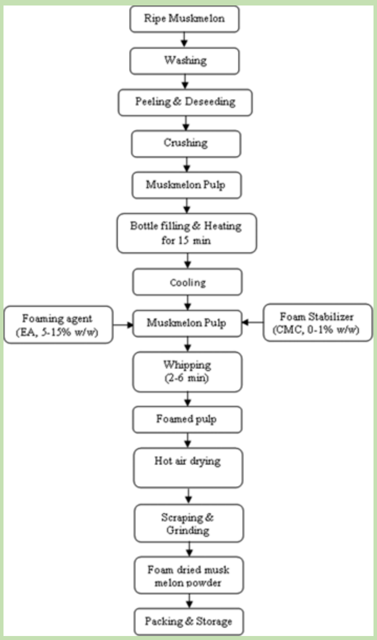
In this drier, belt is in the form of a trough, which is made of metal mesh. Hot air is blown through the mesh and food pieces lying on the trough are dried in the process.

10. Fluidized bed drying:



In this drying method, food pieces are fed on a porous plate and hot air is blown up from the pores through the food particles with just enough force to suspend them in a gentle boiling motion. The fresh food is fed from one side of the drier and dried food is removed from the other end.

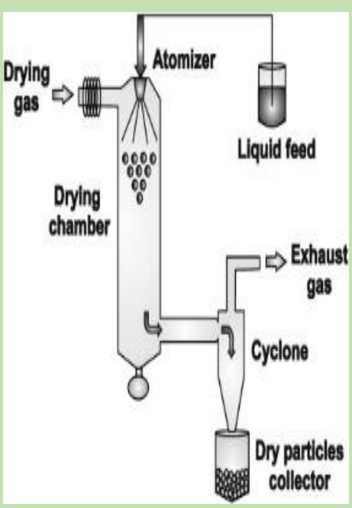
11. Foam mat drying:



Pulps and concentrates are dried by this method. Small amounts of a foaming agent are mixed with the fluid food material and whipped to form low density stable foam. Foams are cast in thin layers onto trays or belts. Foaming is done to expose enormous surface area for quick moisture escape resulting in rapid atmospheric drying at somewhat lower temperature. This is dried by spreading foam on trays as a mat at low temperature. Such dehydration method is known as foam mat drying.

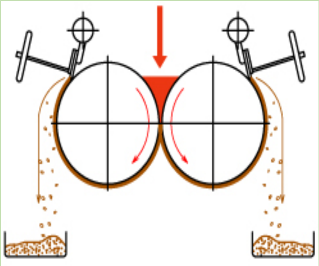
This process takes less time to dry and the dried product can be easily reconstituted. This method is comparatively cheaper than drum drying, spray drying and puffing methods. Orange, tomato, pineapple, and lemon juice powder, apple sauce, baby foods are the products made using this drying technology. The foaming agents used are glycerol monostearate (GMS), egg albumin, guar gum, groundnut protein isolate, carboxy methyl cellulose.

12. Spray drying:



Spray drier is used to dry purees, low viscosity pastes and liquids, which can be atomized. The material is sprayed in a rapidly moving current of hot air. The dried product drops to the bottom of the drying chamber and is collected. Atomization into minute droplets results in drying in a matter of seconds with common inlet air temperature of about 200°C and properly designed system quickly removes the dried particles from heated zones. This method of dehydration can produce exceptionally high quality with many highly heat sensitive materials including milk and coffee.

13. Drum or roller drying:

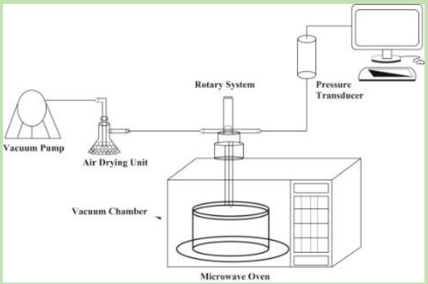


Foods in the form of puree and liquid are dried using this method. This kind of processing is used for preparation of mango flakes, orange flakes, baby foods etc. The pulp of fruit is blended with a small quantity of edible starch and then the blend is adjusted for acidity. The mixture is poured little by little on to heated drum which are made of stainless steel. Drums are revolving at a slow speed. The product dries in the form of a continuous thin sheet or powder. This is broken into small pieces which are then collected in a tin container. Lid has to be placed immediately because the flakes are highly hygroscopic. Drum drying is one of the most energy efficient drying methods and is particularly effective for drying high viscous liquid or pureed foods.

14. Microwave drying:

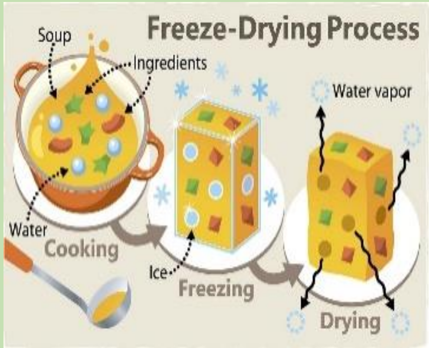
In this method, microwaves are used to dry the food product.

15. Vacuum puffing and dehydration:



For drying at comparatively low temperature, vacuum driers are necessary. Puffing of food is obtained by sudden application of vacuum. Generally used for preparation of orange juice powder or preparation of potato pieces with porous structure. Potato pieces are cooked and while hot they are subjected to vacuum for a short period and then dried. The instant flashing of water vapour from inside leaves the texture porous and also facilitates quick drying.

16. Freeze drying:



Foods in the pieces and liquids are dried by this method. Fruit juice concentrates are manufactured using freeze drying. The material is frozen on trays and then dried under vacuum. Due to vacuum drying, the material dries directly without passing through the intermediate liquid stage. The principle behind freeze drying is that under certain conditions of low vapour pressure, water can evaporate from ice without the ice melting.

Freeze drying is generally used to dry sensitive and high value liquid as well as solid foods such as juices, coffee, strawberries, chicken dice, mushroom slices etc. The dried product is highly hygroscopic and reconstitutes readily. Taste, flavour and reconstitution property of fruit juice concentrates is excellent. Method is costly because of the equipment cost. Freeze drying in combination with air drying is advantageous in reducing cost of drying. For example- vegetables pieces may be air dried to about 50 per cent moisture and then freeze dried down to 2-3 per cent moisture.

17. Accelerated freeze drying (AFD):

This is used for drying pieces of food material without disturbing their shape and texture. Product has good reconstitution property, taste and flavour. The pieces of material are kept pressed between two perforated or wire mesh trays inside a cabinet freeze drier. As the material dries, the bulk of the pieces is gradually reduced by decreasing the clearance between the trays is reduced. The dried material retains its shape and regains it on rehydration. Meat etc. are dried using this technique.

Process of Drying

Whether by sun drying or dehydration, process of drying consists of following steps:

- Selection: The fruits should be in mature condition, sound and firm. Different lots at various stages of maturity must not be mixed together; as this results in a poor dried product.
- Sorting: It is done to remove any decayed parts. Damaged parts which have been attacked by insects, rodents, diseases etc. and parts which have bad appearance must be removed.
- Washing: Thorough washing of vegetables is required to reduce microbial load.
- Peeling: It can be done by peelers, knives or by machines – for thick skinned vegetables – dipping in a solution of lye (dilute NaOH solution) which helps in easy removal of peel.
- Subdivision of raw material: It involves cutting or sectioning of fruit or vegetables. It is very important to have all slices in one drying lot of the same size. Uneven slices result in poor quality end product.
- Blanching: The product is partially cooked when it is dipped in hot water or by exposing it to steam. Blanching helps in inactivating enzymes and prevents discolouration. It destroys oxidizing enzymes, as a result there is better retention of vitamins A and C, removes pungent flavour and shortens drying time.
- Sulphiting/ sulphuring: It involves dipping the material in 1-2 per cent potassium metabisulphate (KMS) or exposing the product to sulphur fumes (done in a closed room), respectively. Sulphur prevents mould growth and preserves colour of light coloured vegetables, repels insects and conserves vitamins A and C. Carotenoids are preserved by coating with starch. Food is exposed to sulphur fumes in such a way that 1000-3000 ppm of it is absorbed. Sulphuring of the fruit is done at the rate of 1.8 – 3.6 kg of sulphur per tonne of fruit. After sulphuring, the trays are kept in the sun with occasional turning of the fruit till it is dried.
- Drying: Product is kept for drying.
- Sweating: Dried product is kept in heaps in a room for few weeks for moisture equilibrium.
- Packing: Plastic or polythene covers can be used. Aluminum foils, cardboard (wax lining is necessary for card board and wooden containers) etc. can also be used. Tin as such is not suitable as it becomes rusty but can be used after coating with inert gas like N2.

- Some fruits and vegetables, in particular, banana, apples and potatoes go brown very quickly when left in air after peeling and slicing; this discolouration is due to phenol oxidase. To prevent slices from going brown, they must be kept under water until drying can be started. For certain fruits like grapes, figs etc. alkali (lye) dipping is done to help quicker drying due to appearance of cracks using 0.1-1.5 per cent Na_2CO_3 solution. Acid dipping for apples and pears is done to prevent browning using 1 per cent ascorbic acid and 1.25 per cent malic acid.

Spoilage of Dried Food Products

Insects like beetles and moths attack the dried food products. Prevention can be done when product is
Storage and curative steps for dried food products

1. Heating: Dried fruits are to be dipped in hot water and dried at 54-65°C in water containing salt solution (dilute) or $NaHCO_3$ can also be used for short time, then remove and re-dry it. It destroys insects and their formative stages.
2. Fumigation: The dried product is exposed to fumes or chemicals like ethylene dichloride, ethylene oxides, carbon tetrachloride and it kills insects including their eggs.

PRESERVATION BY USE OF HEAT

Heat application is one of the most important methods of food preservation and it finds very wide applications amongst various other means of preserving foods. Heat treatment kills both pathogenic and spoilage microorganisms or suppresses their growth and inactivates enzymes. Heat can be applied in different forms such as blanching, pasteurization, sterilization and canning.

Blanching

Blanching is used for variety of purposes. It is defined as a mild heat treatment applied to tissue (usually plant) primarily to inactivate enzymes prior to freezing, drying or canning. It is also known as scalding.

Functions of blanching

- ✓ Inactivate most enzymes
- ✓ Some cleaning action
- ✓ Removes substances in some products
- ✓ Activates some enzymes (if controlled)
- ✓ Removes undesirable odours/ flavours
- ✓ Softens fibrous material and decreases volume
- ✓ Expels air and respiratory gasses
- ✓ Preheating of product prior to canning
- ✓ Reduces number of microorganisms

Major function of blanching is inactivation of enzymes for frozen or dehydrated foods as enzymes can cause rapid changes in colour, flavour and nutritive value of such food products. Moreover, freezing and dehydration processes involve temperatures which are insufficient to inactivate enzymes. Blanching as a pretreatment before drying has many advantages like it helps in cleaning the material and reducing the amount of microorganisms present on the surface; it preserves the natural colour in the dried products; for example, the carotenoid (orange and yellow) pigments dissolve in small intracellular oil drops during blanching and in this way they are protected from oxidative breakdown during drying; and it shortens the soaking and/ or cooking time during reconstitution. Blanching does not allow effective autoclaving, and stops the activity of autolytic enzymes.

For canned products, blanching removes gases, shrinks the food to correct fill weight in can and offers preheating, which are very important to provide vacuum in can and proper sterilization. Sometimes canning process may allow sufficient time for enzymatic activity and under blanching may increase the enzymatic activity.

Fruits are not blanched. As a thumb rule, all those vegetables which cannot be eaten raw are blanched. E.g. potatoes, greens green beans, carrots, okra, turnip and cabbage should always be blanched. On the other hand, blanching is not needed for onions, leeks, tomatoes and sweet peppers.

Using sodium bicarbonate with blanching water preserves the green colour of vegetables by preventing the conversion of chlorophyll into pheophytin, unattractive brownish-green colour compound.

Methods of blanching:

Blanching is a delicate processing step. It requires careful monitoring of time, temperature and the other conditions. Effective blanching time necessary to inactivate enzymes is dependent on various factors viz. type of food, method or type of heating, product size and temperature of heating medium etc. There are mainly two typical methods of blanching based on type of heating medium viz. hot water blanching and steam blanching use hot water and steam as heating medium, respectively. The former process involves temperatures below 100°C whereas the latter is carried out at temperatures above 100°C. A third type of blanching system exists which is a combination of hot water and steam blanching.

Blanching of green leafy vegetables especially spinach at boiling point causes loss of green colour but at lower temperature (77°C), it retains the natural green colour, even when heated at higher temperature (121°C) later during sterilization. At lower temperature, the enzyme chlorophyllase remains active for little time and converts chlorophyll to a phyllin, which retains green colour.l

Hot water blanching:

In this method, the cleaned food is subjected to hot water (85 to 100°C) until the enzymes are inactivated. Pot blanchers are used at home scale. Generally hot water blanching is done because of low capital costs and better energy efficiency. Disadvantages associated with hot water blanching include loss of water-soluble constituents, risk of contamination and higher cost of water and disposal of effluent.

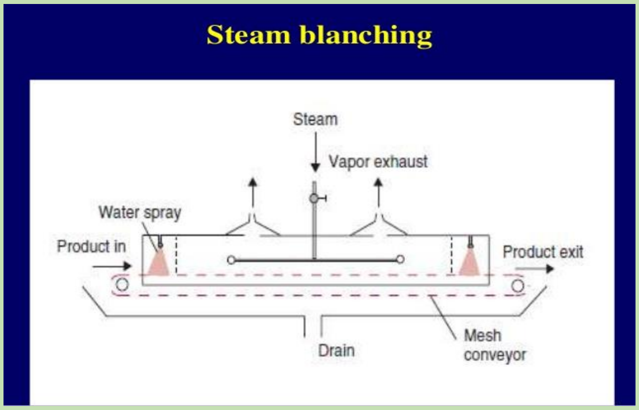
Steam blanching:

In case of steam blanching, the food product is directly exposed hto steam, which avoids the loss of food soluble solids (flavours, vitamins, acids, sugars etc.) to blanching medium as well as solves the problem of disposing blanching medium after processing. Steam blanching is advantageous as it results in less loss of water-soluble constituents, less volume of waste, easy to clean and sterilize. But it has some disadvantages such as higher capital costs, uneven blanching, and low efficiency.

Central Institute of Agricultural Engineering (CIAE), Bhopal has developed the batch type steam blancher, (Figure 2) with 100 kg/ h capacity. It has been evaluated for blanching of cabbage, cauliflower, pea and okra. Results revealed satisfactory performance on account of colour retention in the dried product.

On commercial level, tunnel steam blanchers with product conveyers are used.

Blanchers with hot water and steam system:



This type involves three step process viz. product on conveyer belts is exposed to steam consecutively followed by contact between food and hot water and finally immersion in hot water.

Efficacy of blanching:

There are various types of enzymes such as lipoxygenase, polyphenolase, polygalacturonase and chlorophyllase, which cause loss of quality and therefore, must be inactivated. Normally, two heat resistant plant enzymes such as catalase and peroxidase, are used to evaluate blanching efficacy, as appropriate time and temperature is required to inactivate them.

Pasteurization

Pasteurization is a mild heat treatment for relatively brief duration to kill part of the microorganisms and to eliminate human pathogens present in food. It is used specially when the aim is to kill pathogenic microorganisms and where the spoilage organisms are not very heat-resistant and the product cannot stand high-temperatures or frozen.

The main purpose of pasteurization in low acid foods is destruction of pathogenic microorganisms whereas in acid foods it aims at killing spoilage microorganisms along with enzyme inactivation. For example pasteurization is used to kill pathogenic microorganisms Brucella abortis, Mycobacterium tuberculosis and Coxiella burnetti in case of milk (63°C for 30 minutes; 71.5°C for 15 seconds) and spoilage microorganisms in beers (lactic acid bacteria and yeasts at 65°C–68°C for 20 minutes in bottle), fruit juices (yeast and fungi along with pectinesterase and polygalacturonase inactivation at 65°C for 30 minutes; 77°C for 1 minute; 88°C for 15 seconds) etc. In addition to destroying some microorganisms, pasteurization also inactivates some enzymes. Pasteurization does not change the colour and flavour to any significant level.

Since pasteurization does not kill all the microorganisms, this process is usually combined with another preservation method like refrigeration, freezing etc. Typical other preservation methods used in combination with pasteurization include refrigeration as in the case of milk; chemical additives- pickles, fruit juices; fermentation (additives)- sauerkraut, cheeses; and packaging (anaerobic conditions)- beers, fruit juices.

The index microorganism for pasteurization is Mycobacterium tuberculosis. If this microorganism is killed by pasteurization it is assumed that all other pathogens are also destroyed.

Methods of pasteurization

Three methods of pasteurization are used viz. low temperature long time (LTLT), high temperature short time (HTST) and ultra-high temperature (UHT) method.

Low temperature long time (LTLT) method:

In LTLT pasteurization, the pasteurization time is in the order of minutes and related to the temperature used; two typical temperature/time combinations are used: 63 to 65°C over 30 minutes or 75°C over 8 to 10 minutes. The minimal heat treatment for market milk is 62.8°C for 30 minutes in (LTLT) holding method and for grape juice is 76.7°C for 30 minutes.

High temperature short time (HTST) method:

Rapid pasteurization involves temperatures of about 85° to 90°C or more and time in the order of seconds. HTST method involves temperature of 71.7°C for about 15 seconds in case of milk pasteurization and grape wines are generally pasteurized for one minute at 81 to 85°C.

Ultra high temperature (UHT) method:

Rapid, high or flash pasteurization involves temperatures of 85-90°C or more and time in order of seconds. These are also known as ultra-high temperature (UHT) treatments. Typical temperature/time combinations may be: 88°C for 1 minute; 100°C for 12 seconds; 121°C for 2 seconds. This treatment will destroy all but the most heat resistant spores resulting in commercially sterile product.

Bacterial destruction is very nearly equivalent in all temperature-time combinations; however, the 121°C for 2 seconds treatment gives the best quality products in respect of flavour and vitamin retention. Very short holding times to the tune of seconds, however, require special equipment which is more difficult to design and generally is more expensive than the LTLT/ HTST type of processing equipment.

Sterilization

Sterilization refers to complete destruction of microorganisms. It requires heat treatment of 121°C for 15 minutes which destroys all spores. But it has severe effect on heat sensitive nutrients and proteins through maillard reaction. The temperature and time required to sterilize the food varies with the type of food. Such high temperatures can be created by steam under pressure in steam pressure boilers/ sterilizers. Temperature at sea level is 100°C at atmospheric pressure but with 15psi temperature of 121.5°C can be achieved.

Commercial sterilization:

Commercial sterility is achieved when all pathogenic and toxin forming microorganisms have been destroyed along with the spoilage microorganisms. Usually target organism is a heat resistant microorganism, most often a spore or schlerotia forming organism rather than a vegetative one (e.g. spore forming anaerobic bacteria – Clostridiumbotulinum). Such foods may contain viable spores but these are not able to grow under normal conditions. If packaged aseptically, these products can be marketed without refrigeration. These products generally have a shelf life of 2 years or more.

Canning

Canning is the process of applying heat to food that's sealed hermetically in a jar to destroy any microorganism that can cause food spoilage.

The food preservation process of canning originated in 1809 when French confectioner Nicolas Appert succeeded in preserving meats in glass bottles that had been kept in boiling water for varying periods of time. In the honour of inventor, canning is also known as "appertization". Canning demonstrates that food can be preserved for quite a longer duration of time when heated and stored in anaerobic condition. Today, the method of canning is one of the most widely used methods for food preservation.

In canning the food is placed in containers, heated, and then sealed, usually under vacuum. It is used for products such as fruit juices, syrups, and sauces. Canning process is advantageous in retaining the stable vitamins and colour and flavour of food items.

Unlike pasteurization, canning of foods normally involves exposure for longer periods of time to higher temperatures created by steam under pressure in order to kill endospore-forming microorganisms. Steam under pressure (e.g. a pressure cooker) is the most effective method since it kills all vegetative cells and spores. The heat treatment generally exceeds 100°C temperature and the food is heated long enough to inactivate the most heat-resistant pathogens (disease-causing organisms) and spoilage organisms. Heating to such high temperatures is achieved by steam injection, which is followed by rapid cooling. Factors affecting the length of time the food must be heated include the kind and number of microorganisms present, acidity of foods, presence of preservatives (salt, sugar). The only dangerous spore forming bacterium which survives the treatment is Clostridium botulinum

The whole process of canning includes preparation of food, filling, exhausting, sealing, thermal processing i.e. autoclaving and cooling.

1. Preparation of food:

Preparation of food involves processes like washing, grading, peeling, sub sizing and blanching. High pressure water sprays are most effective means of washing food items. Grading is done by passing food products through screens of various diameter sizes. Visual inspection based on weight, shape and colour may also be performed for grading. Fresh vegetables, fruits or meat of high quality are selected and made free of all dirt and undesirable parts in order to reduce bacterial load and to preserve the best portion of the product.

The cleaned food is subjected to hot water or steam blanching. This treatment inactivates enzymes, removes respiratory gases, promotes shrinking, fixes the natural colour of the product, and pre-heats the product to help in vacuum formation in the can.

2. Filling of cans:

The hot food is then filled into pre-heated cans. Cans are also kept hot in order to expand the food, remove air or gas trapped within. Containers are not completely filled with food. Headspace of not more than 10 per cent of the total container volume is maintained for expansion of food during heating.

After filling, syruping or brining is done usually in case of fruits and vegetables, respectively.

3. Exhausting:

Exhausting is removal of air from the cans before they are closed. It reduces the pressure strain on can seams and internal corrosion and also conserves quality of product.

4. Sealing:

Cans are sealed immediately after exhausting with the help of a double seam can sealer. Precaution must be taken that the temperature of food should not fall below 74°C while sealing.

5. Thermal processing:

After sealing cans are subjected to heat treatment in the form of steam under pressure in canning retorts or pressure canner to effect sterilization of contents. Heating medium can be boiling water or steam depending on the pH of the food.

Foods with acidic pH i.e. pH below 4.5, may require only immersion of cans in boiling water. Non-acid foods, i.e. pH above 4.5, however, need to be subjected to 15 psi pressure (116°C-121°C) for one to two hours. Meats may take a longer time. The amount of time will also depend upon the load of the retort and size of the cans. Heavily loaded autoclaves will take more time. Larger the can greater is the processing time.

The retorts can be batch or continuous type. Fruits and acid vegetables are processed in open type cookers whereas low acid vegetables are processed in closed retorts under steam.

6. Cooling:

After processing, the cans are cooled immediately to 39°C to stop cooking process and to prevent over heating/ burning. In addition, thermophilic bacteria surviving heat treatment will not be allowed to germinate. Usually cans are dipped in cold water.

7. Storage:

After labeling, cans are kept in wooden boxes or corrugated carboard cartons and stored in cool and dry place.

Aseptic canning:

Aseptic canning is a technological advancement of canning process. This technique was developed by Martin in 1950. In this method, sterilized food is aseptically filled in pre-sterilized cans which are subsequently sealed in an aseptic environment. This method avoids the typical steps like in-can thermal processing and subsequent cooling of canning. Flash pasteurization is used to sterilize the food. It involves four steps which are carried out in a sequential manner in a closed interconnected apparatus: (a) sterilization of food by appropriate flash heating, holding and cooling, (b) sterilization of cans and lids with super heated steam, (c) aseptic filling of cooled sterile food into sterile cans, and (d) aseptic sealing of cans with lids. For example- Tetra Pak system . Aseptic canning yields better quality of product in terms of colour, flavour, texture and nutrient retention and shelf life.

Hot pack:

It is also known as hot fill. This method involves filling of pre-pasteurized or pre-sterilized food while still hot in clean containers but not essentially sterile containers under clean but not necessarily aseptic conditions. For example- filling of jam while still hot in clean bottles.

PRESERVATION BY USE OF SALT AND SUGAR

Introduction

Sugar and salt in high concentrations have high osmotic pressure and draw water from microbial cells or prevent normal diffusion of water into these cells resulting in a preservative condition.

Principle of Preservation by Salt

Salt acts as preservative when its concentration is increased above 12 per cent. Salt levels of about 18 to 25 per cent in solution generally will prevent all growth of microorganisms in foods. However, this level is rarely tolerated in foods except in the case of certain briny condiments. Salt exerts its preservative action by plasmolysis of microbial cells due to high osmotic pressure, drawing moisture from microbes, ionizing to yield chloride ion, which is harmful to microorganisms, reducing the solubility of oxygen to water, sensitizing the cells against carbon dioxide and interfering with the action of proteolytic enzymes.

Salt preserved Food Products

Salting or Curing

Salting is being done in case of meat and fish preservation since ancient times. Curing draws moisture from the meat through osmosis and makes it unavailable for microbial growth and enzyme action and hence, food is preserved. Meat is generally cured with salt or sugar, or both. Nitrates and nitrites are also often used to cure meat and contribute towards the characteristic pink colour, as well as inhibit Clostridium botulinum. Dry salting is used in India for the preparation of preserved tamarind, raw mango, aonla, fish and meat.

Pickles:

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are the relishing accompaniments in the Indian as well as continental meals. They are known to be good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion.

The preservation by picking is achieved by conversion of fermentable carbohydrates into organic acids mainly lactic acid, preservative action of salt, vinegar and other ingredients and antimicrobial activity of organic acids, oil and spices. Pickling occurs due to fermentation by lactic acid bacteria, which are generally present on surfaces of fresh fruits and vegetables. These bacteria can grow well in acidic medium and can tolerate 8-10 per cent salt concentration. Whereas, undesirable microorganisms do not grow well in acidic solutions and this is the basis of preserving fruits and vegetables by pickling. Some of the fruits and vegetables, which are generally pickled as they undergo lactic acid fermentation, are raw mangoes, limes, Indian gooseberry (aonla), ginger, turmeric, cabbage, cauliflower, broccoli, carrot, turnips, radish, cucumber, olive, garlic, apples, pear, green plums, lemons, banana and green chillies.

Methods of Pickling

Pickling uses the salt combined with the acid, such as acetic acid (vinegar), oil and spices. Based on the ingredients, the pickles differ. Different methods of pickling are:

- Pickles with salt
- Pickles with vinegar
- Pickles with oil
- Pickles with salt, vinegar, oil and spices

Pickles with salt

Vegetables are usually preserved by salting. Salt content of 15 per cent or above prevents microbial spoilage as well as inhibits enzymatic browning and discolouration. Salting improves the taste and renders firmness in tissues of vegetables and controls fermentation. This method is suitable for vegetables as they contain very little sugar, as a result lactic acid is not formed in sufficient amounts to act as preservative. However, some fruits viz. mango, lemon, etc. are also preserved with salt.

Pickles with vinegar

Vinegar pickles are the most important pickles consumed in other countries. Vinegar in concentrations up to 4 per cent acetic acid and higher concentrations has bacteriostatic and bactericidal action, respectively. The final concentration of 2-3 per cent acetic acid is required to ensure preservation. For this, 6-9 per cent acetic acid vinegar is used, to overcome dilution by water oozing out of tissues. Such higher concentration helps to expel the gases present in the intercellular spaces of vegetable tissue. In vinegar pickles, salt (2-3 per cent) and sometimes sugar (2-5 per cent) are also added. If the vinegar concentration is lower than 2 per cent, vinegar pickles need to be subjected to pasteurization in order to assure their preservation. Mango, garlic, chilies, etc. are preserved in vinegar.

Pickles with oil

Highly spiced oil pickles are quite popular in India. Oils like mustard oil, rapeseed oil, sesame oil are generally used for pickling. The fruits or vegetables should be completely immersed in the edible oil. Cauliflower, lime, mango and turnip pickles are the most important oil pickles. The pickle remains in good condition for one to two years if handled properly.

Pickles with salt, vinegar, oil and spices

This method combines the advantages of fermentative action of salt and the preservation action of both vinegar and oil. The flavouring and antibacterial property of spices is also made use of in this kind of pickle. The powdered spices are usually fried in oil and mixed to the prepared fruit/ vegetable before the addition of vinegar.

Principle of Preservation by Sugar

Sugar in high concentrations acts as a preservative due to osmosis. Sugar attracts all available water and water is transferred from the microorganisms into the concentrated sugar syrup. The microflora is dehydrated and cannot multiply further.

The concentration of sugar in sugar preserved products must be 68 per cent or more, which does not allow microorganisms to grow. Lower concentrations may be effective but for short duration unless the foods contain acid or they are refrigerated. The critical concentration of sugar required to prevent microbial growth varies with the type of microorganisms and the presence of other food constituents.

Some of the most popular preserves with sugar are jelly, jam and marmalade. These are the stable gels. Pectin, a natural component of fruits, forms a gel only in the presence of sugar and acid. Sugar prevents spoilage of jams, jellies, and preserves even after the container is opened.

With the use of sugar, the water activity cannot be reduced below 0.845. This level of water activity is sufficient to inhibit mesophillic bacteria and yeast but does not check mould attack. Due to this, various other methods are also adopted to prevent mould development in sugar preserved products like finished product pasteurization (jams, jellies, etc.) and use of chemical preservatives in order to obtain the antiseptisation of the product surface.

Most of these products are made of acid fruits. When foods low in acid are used, they are usually combined with some acid fruit. Besides contributing flavour to the product, the acid aids in the preservation. The amount of sugar used in manufacture of these products varies widely.

Sugar Preserved Food Products

Based on the form in which the fruit is used, preserved products may be classified as:
Jams, jellies, marmalade, cheese, toffee made from fruit in small pieces/ pulp/ juice
Preserves, crystallized, glazed, candied fruits made from whole fruit/ big pieces

Jam

Jams are usually made from the pulp of the whole fruit. Three constituents namely pectin, sugar and acid are mimportant in the preparation of jam. It can be made from one kind of fruit or from two or more kinds. Jam should have fruit content of at least 40 per cent and a total sugar content of not less than 68 per cent to prevent mould growth after opening the jar. Jams contain 0.5-0.6 per cent acid and invert sugar should not be more than 40 per cent. In India, fruits good for making jams are pineapples, mango (both ripe as well as raw), peach, pear, karonda, papaya, carrot, plum, apricot, apple, strawberry and gooseberry (rasbhari).

The whole fruit (strawberry, gooseberry) or the chopped pulp (mangoes, peaches, apples) of the fruit is cooked with a certain quantity of sugar (0.75 to 1.0 kg sugar for 1.0 kg fruit pulp) to a setting consistency, thick enough to hold the fruit tissues in position. If the fruit is not acidic enough, citric acid or lime juice is added to improve the flavour and the setting property.

Jelly

Jelly is a crystal-clear jam but made only from the juice of the fruit. A clear juice extract, containing enough amount of pectin and acid, is boiled with certain proportion of sugar (0.75 to 1.0 kg sugar for 1.0 kg extract) to a consistency at which it will set on cooling. A perfect jelly should have a beautiful colour, should be transparent and firm, and on touching should quiver; it should not be syrupy like honey, sticky or have crystallized sugar; one should be able to cut it with a spoon and the spoon should come out clean.

Fruits like guava, apple, plum, karonda and papaya are generally used for jelly making. Some fruits which do not contain enough pectin like apricot, pineapple, strawberry, raspberry etc. can be used for jelly preparation only after addition of pectin powder.

Marmalade

Marmalade is made with the juice extract of citrus fruits like oranges and lemons with thin slices of the skin or the fruit suspended in the clear jelly-like mixture. Pectin and acid are both essential for the jelly-like consistency of marmalades. The proportion of sugar to juice is the same in a jelly.

Fruit bar or leather

In this, the fruit pulp is taken and its total soluble solids (TSS) content is raised to 30°Brix by adding sugar. This pulp is then spread on stainless steel trays smeared with fat which are dried in a mechanical dehydrator at 60±5°C for 2 hours. Potassium metabisulphite is added at the rate 0.2 per cent in the fruit pulp. Thin layer of pulp is dried on a pre-greased stainless steel or aluminum tray followed by second layer. Usually five layers are dried one above the other and the final product is packed in polythene bags. Fruit leather can be prepared from different fruit pulps like mango, peach, plum, apricot, papaya, etc.

Fruit toffees

Fruit toffees are made by mixing fruit pulp with other ingredients like glucose, milk powder and edible fat. The fruit pulp is first concentrated to half its volume in a steam jacketed kettle or pan over steam bath. Generally, for one kilo gram of concentrated pulp, 160 g of glucose, 320 g of milk powder and 200 g of edible fat is added. This mixture is further heated to a thick consistency (75- 80°Brix) followed by spreading it as a sheet of one cm thickness on a fat smeared flat tray and allowed to cool. Then these are cut into pieces (called as toffees) of desired size, wrapped and stored it in cool dry place.

Preserves or murabbas

A preserve is a product in which a mature fruit/ vegetable or its pieces are saturated with heavy sugar syrup. Shape of the fruit or the pieces is carefully preserved. Fruit pieces should remain tender, plump, glistening, firm and transparent. Care should be taken so that the flavour of the fruit is not masked by an excess of sugar. Fruits like Indian gooseberry (aonla), wood apple (bael), apple, pear, mango, cherry, karonda, papaya, pineapple and strawberry can be used for making preserves. These are made either with the whole fruit; particularly if the fruit is small in size or with uniformly cut pieces of the fruit like in the case of apples.

Candied fruits

Candied fruits are first impregnated with cane sugar or glucose syrup and subsequently drained free of syrup and dried. These must be plump, tender and have highly flavoured sweet taste without any stickiness. The most suitable fruits for candying are aonla, karonda, pineapple, cherry, papaya, apple, peach and peels of orange, lemon, grapefruit, ginger etc.

Glazed fruits

Candied fruits covered with a thin transparent coating of sugar, which imparts them ba glossy appearance, are known as glazed fruits.

Crystallized fruits

Candied fruits when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from dense syrup are called crystallized fruits.

PRESERVATION BY LOW TEMPERATURE

Use of low temperature is the easiest, most convenient and least time-consuming method of preserving foods. Refrigeration/ freezing do not sterilize foods or destroy the microorganisms that cause spoilage. It simply slows the growth of microorganisms and the chemical and enzymatic changes that affect quality or cause spoilage.

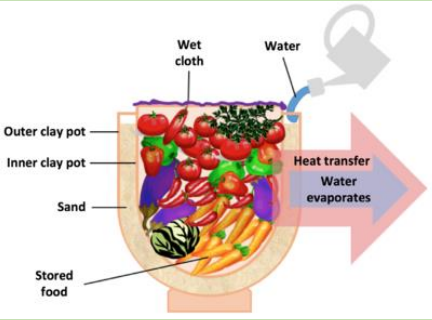
Low temperature preservation is less effective as compared to thermal techniques of food preservation because microorganisms are more likely to be able to survive cold temperatures than hot temperatures. One of the problems related to use of freezing as a method of food preservation is that microorganisms are only deactivated and not killed, which may again become active while thawing. Similarly enzyme action is slowed but not stopped during freezing and these enzymes are responsible for colour and flavour changes and loss of nutrients during refrigerated storage.

Principle

Low temperatures retard chemical reaction and action of food enzymes and slow down or stop the growth and activity of microorganisms in foods. As a rule of thumb, for every 10°C temperature change, the rate of reaction changes by a factor of 2 to 3. Pathogen growth is halted below -4°C and spoilage microorganisms don't grow below -10°C.

Ways of Preserving by Low Temperature - The different ways of preserving the food by using low temperatures are -

Evaporative cooling:



Evaporative cooling can be practiced in conditions where no electricity is available for cooling and storing the harvest. It is based cooling by evaporation of water from the system. Water takes energy from its surroundings for evaporation. Coolers based on this principle are called as evaporative coolers. These work best in hot and dry climates. When hot and dry passes over a wet surface; the rate of evaporation is faster resulting in greater cooling. The efficiency of an evaporative cooler depends on the humidity, temperature and movement of the surrounding air and surface area of food product. Examples of evaporative coolers are Janta cooler, pot in pot cooler, which are movable in nature and static cooler named zero energy cooling chamber.

Janta cooler

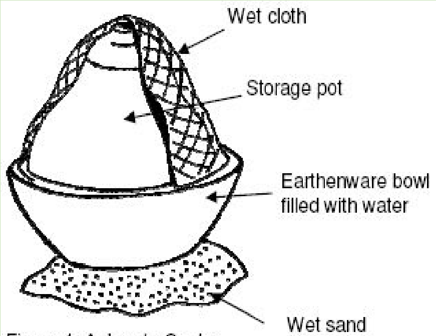
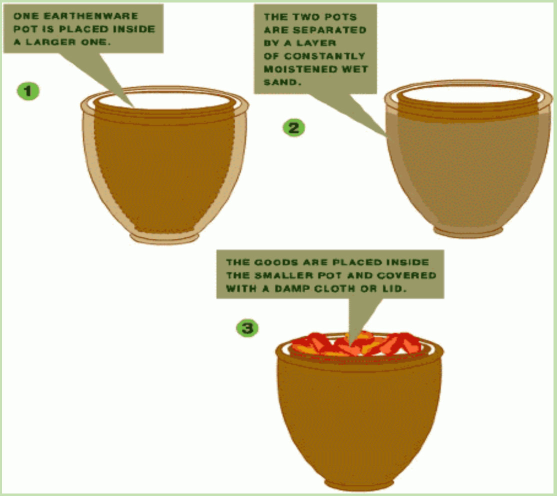


Figure 1: A Janata Cooler
Illustration: Practical Action / Neil Noble.

Janta cooler have been developed by Food and Nutrition Board (FNB) of India. It has smaller storage pot placed in a bigger earthen pot filled with water. The bigger earthen pot is kept on wet sand. The inner pot stores the fresh food commodities, which is covered by a damp cloth that is dipped in the water pool. Cloth draws water from the pot and gets wet. Water evaporates from the wet cloth and keeps the storage pot cool.

Pot in pot cooler



Pot in pot cooler was developed by a Nigerian teacher Mohammed Bah Abba. It is also known jas zeer storage. In this cooler, two pots of different sizes, smaller one lying inside the bigger pot separated by the wet sand. The inner pot is used for storage of fresh produce. Use of this system for cooling increases the shelf life of vegetables from 2-4 days to 17-20 days.

Zero energy cool chamber (ZECC)

Zero energy cool chamber is a immovable cooling chamber developed by Indian Agricultural Research Institute (IARI), New Delhi, for short duration storage of fruits and vegetables on the farm. It is a double walled structure and the gap of about 75 mm (3”) between the two walls is filled with sand. It is covered by a cover made of cane or sack. The sand is saturated with water to keep it moist. As the water evaporates, it removes the heat from within the chamber through the process of evaporative cooling. The chamber can keep the temperature 10-15°C cooler than the outside temperature and maintain about 90 per cent relative humidity. It is suitable for almost all fruits and vegetables except onion, garlic, ginger, potato etc., as these crops require lower relative humidity (65-80 per cent).

Walk-in Evaporative cool chamber

These are enlarged versions of ZECC and require electricity to run exhaust fans for better air circulation and cooling. Big walk-in chambers of 2 meters' height are made wherein the fruits and vegetables are kept in plastic crates.

Cellar Storage

In cellar storage structures, temperatures are reduced slightly below room temperature (about 15°C). These are underground rooms, which are well insulated to outside temperatures and have proper ventilation. These are meant for short term storage of root crops, potatoes, apples etc. during the winter months as the temperature is not low enough to prevent the action of many spoilage organisms or the plant enzymes. However, deterioration is slowed down considerably. Humidity should be carefully maintained in the storage cell as high moisture promotes fungal growth whereas shriveling and drying may occur in dry conditions.

Chilling or Refrigerated Storage

Refrigerated storage of food is generally practiced both at home or industry level. In chilling, the temperature of a food is reduced generally to between -1°C and 7°C and thus subsequent storage at refrigerated temperature extends the shelf life of both the fresh and processed foods. It just increases shelf life and has limited application in preserving foods. It is not the sole method for preserving food therefore it is used as an adjunct process to extend the storage life of mildly processed (e.g. pasteurized, fermented and irradiated) and low-acid foods.

Chilling and refrigerated storage retards the growth of bacteria, particularly the thermophiles and mesophiles. Psychrophillic spoilage bacteria however can spoil food during low temperatures storage, but some psychrophillic pathogens, such as Listeria monocytogenes, Yersinia enterocolitica etc. found in refrigerated food need attention. Temperatures of 5 to 6°C or less retard the growth of most food poisoning microorganisms except Clostridium botulinum type E.

Freezing

Freezing is the removal of heat from the packaged or whole foods resulting in the temperatures between slightly below the freezing point of food to -18°C. Frozen foods last many months without spoiling however, some quality loss may occur.

Some microorganisms grow even at sub-freezing temperatures as long as water is available. Conversion of water to ice increases the concentration of dissolved solutes in unfrozen water and leads to low water activity. Freezing prevents the growth of microorganisms due to reduced water activity. The concerted effect of low temperatures, reduced water activity, and pre-treatment of blanching prior to freezing of products yield longer shelf life.

Different types of freezing systems are available for foods. No single freezing system can satisfy all freezing needs, because of the wide variety of food products and process characteristics. The selection criteria of a freezing system will depend on the type of the product, reliable and economic operation, easy cleanability, hygienic design and desired product quality.

Although all commercial freezing processes are operated at atmospheric conditions, there are potential applications of high-pressure assisted freezing and thawing of foods. The pressure–induced freezing point and melting point depression enables the sample to be super cooled to low temperature (e.g. -22°C at 207.5 M pa) resulting in rapid and uniform nucleation and growth of ice crystals on release of pressure.

Freezing systems based on time taken for freezing

Freezing systems based on time required to freeze foods can be classified into two types i.e. slow and quick freezing. Rate of freezing affects the quality of frozen food.

Slow freezing:

Slow freezing occurs when food is directly placed in freezing rooms called sharp freezers. It is also known as sharp freezing. This method involves freezing by circulation of air by convection i.e. through a specially insulated tunnel, either naturally or with aid of fans. The relatively still air is a poor conductor of heat and that is the reason for long time required to freeze the food. The temperature ranges from -15 to -29°C and freezing may take from 3 to 72 hours. The ice crystals formed are large and found in between cells i.e. extra-cellular spaces because of which the structure of food is disrupted. The structure of food is not maintained and thawed food cannot regain its original water content. Large ice crystals create quality problems like mushiness in vegetables etc.

Quick freezing:

Vigorous circulation of cold air enables freezing to proceed at a moderately rapid rate. In this process, the temperature is kept between -32°C to -40°C and the food attains the stage of maximum ice crystal formation in 30 minutes or less. Small ice crystals are formed within the cells and therefore, it does not damage the structure of food. On thawing, the structure of original food is maintained.

Slow vs. quick freezing

The difference between sharp and quick freezing has been given in Table 1 –

Sharp freezing	Quick freezing
• Rates of cooling of less than 1°C/min. Ice crystals form in extra-cellular locations • Large ice crystals formation • Maximum dislocation of water • Shrinkage (shrunk appearance of cells in frozen state) • Less than maximum attainable food quality	• Produces both extra-cellular and intracellular (mostly) locations of ice crystals • Small but numerous ice crystals • Minimum dislocation of ice crystals • Frozen appearance similar to the unfrozen state • Food quality usually superior to that attained by slow freezing

Freezing Systems Based on Mode Of Operation - They are constructed for batch, continuous and batch/continuous modes of operation.

Batch freezing

This type of freezing is mostly used for small operations. If a variety of products are to be frozen, a batch freezer may be selected over continuous as they are more versatile. Such freezing systems are also likely to be used for products with longer freezing times since with a batch freezer there is better utilization of floor space due to the multi-layer arrangement of loading. It is difficult to choose on an exact line of demarcation but generally freezing times longer than one hour would usually require a batch mode of operation.

Continuous freezing

This process of freezing is used in large-scale production lines. Continuous freezers are best used for freezing individual portions, such as small pieces of vegetables. The main advantage in using a continuous freezer for these smaller and/or thinner products is that since they freeze quickly they will also thaw quickly and the delays that occur with a batch-freezing operation may be overcome. Continuous freezing allows quick handling after freezing and a quick transfer to the cold store.

Batch/ continuous freezing

These kind of freezers are usually batch type freezers operated with trolleys which are loaded in sequence at fixed-time intervals rather than all at one time as in the truly batch freezer.

Freezing systems Based on contact with the product

Based on the contact between food and the freezing medium, the freezing systems can be categorized in two categories viz. direct and indirect contact freezing.

Direct contact freezing

In case of direct contact freezers, the product to be frozen is completely surrounded by the freezing medium i.e. the refrigerant, which maximizes the efficiency of heat transfer.

Indirect contact freezing

In this type of freezer, food materials to be frozen are separated from the refrigerant by a conducting material, usually a steel plate/ belt. The food product is indirectly exposed to the freezing medium.

Freezing systems based on heat transfer systems - Different types of freezing methods based on the heat transferring systems are depicted in the

Air

In general, air is used as the freezing medium in the freezing, either as still air or forced air . Packaged or unpackaged solid foods can be frozen in air at temperatures ranging from -18 to -40°C. Different methods are available for freezing by contact with cooled gas.

Still air/ sharp freezing

Please refer to slow freezing.

Cabinet freezing

This method involves circulation of cold air in a cabinet where the product is placed in a tray. The moisture pick-up from the product may deposit on the cooling coils as frost, which acts as an insulation.

Air blast freezing

This method employs the use of high velocity cold air to reduce the temperature of the food. Air velocities between 2.5 and 5 meter per second give the most economical freezing. Lower air velocities result in slow product freezing and higher velocities increase unit freezing costs considerable.

This method can be further divided into fluidized bed freezing, belt freezing, and tunnel freezing, depending on how the air interacts with the product.

Belt freezing

The first mechanized air-blast freezers consisted of a wire mesh belt conveyor in a blast room for continuous product flow. Uniform product distribution over the entire belt is required to achieve uniform product contact and effective freezing. Controlled vertical airflow forces cold air up through the product layer, thereby creating good contact with the product particles and increasing the efficiency. The principal current design is the two–stage belt freezer. Temperatures used are usually -10 to 4°C in the pre-cool section and -32 to -40° C in the freezer section.

Tunnel freezing

In this process, the products are placed in trays or racks in a long tunnel and cool air is circulated over the product.

Fluidized bed freezing

The fluidized bed freezer consists of a perforated bed through which refrigerated air is blowxn vertically upwards. The air velocity must be greater than the fluidization velocity. A schematic diagram of fluidized-bed freezer is shown in This freezing method is suitable for small particulate food bodies of fairly uniform size, e.g. peas, diced carrots, corns and berry fruits. The high degree of fluidization improves the heat transfer rate and results in good use of floor space.

The use of fluidization is advantageous compared with other methods of freezing since the product is individually quick frozen (IQF). The idea of individually quick frozen foods (IQF) started with the first technological developments aimed at quick freezing for the food particles with a tendency to stick together. Small vegetables, prawns, shrimp, french-fried potatoes, diced meat, and fruits are some of the products now frozen with this technology.

Plate freezing

In this method, the product is sandwiched between metal plates and pressure is usually applied for good contact. Most familiar types of such freezers include vertical plate freezers and horizontal plate freezers based on loading of food in freezer. Plate freezers are only suitable for regular-shaped food materials such as blocks, packages and cartons. Batch freezing is the most common for plate freezers, however some are available for a continuous operation. When the product has been frozen, hot liquid is circulated to break the ice seal and defrost. Spacers are used between the plates during freezing to prevent crushing or bulging of the package. Temperatures are between -17°C to -45°C.

Immersion freezing

In this method, the food is immersed in low-temperature brine to achieve fast temperature reduction through direct heat exchange. The refrigerating fluids usually used are salt solutions (sodium chloride), sugar solutions, glycol and glycerol solutions, and alcohol solutions. These should have low boiling points. Immersion freezing is advantageous as compared with air blast freezing in terms of reduced weight loss by evaporation.

Refrigerant must be non-toxic, pure and should not contribute to taste or flavour of food. Covering food with flexible membranes, which allow rapid heat transfer, may be done to prevent contact between food and liquid refrigerants.

Immersion freezing with the use of liquids has now only a limited use. Nowadays, liquefied gases have replaced the salt/ sugar solutions and are used mainly for continuous freezing processes.

Cryogenic freezing

Cryogenic freezing, is one of the fast, flexible and cheap method of freezing. In this, the liquefied gases are placed in direct contact with the foods. The three liquefied gases most commonly used as refrigerants are nitrogen, carbon dioxide and liquid freon freezant (CCl_2F_2). Unlike nitrogen and carbon dioxide, most of the refrigerant is recondensed and used again, resulting in reduction of cost. The product can be exposed to a cryogenic medium in three ways:

- ✓ The cryogenic liquid is directly sprayed on the product in a tunnel freezer.
- ✓ The cryogenic liquid is vaporized and blown over the food in a spiral freezer or batch freezer.
- ✓ The product is immersed in the cryogenic liquid in an immersion freezer.

Food is exposed to an atmosphere below -60°C through direct contact with liquid nitrogen or liquid carbon dioxide or their vapour. This is a very fast method of freezing, thus adequate control is necessary for achieving quality products. It also provides flexibility by being compatible with various types of food products and having a low capital cost. The rapid formation of small ice crystals greatly reduces the damage caused by cell rupture, preserving colour, texture, flavour and nutritional value. The rapid freezing also reduces the evaporative weight loss from the products, provides high product throughout and has low floor space requirements. The advantages of liquid nitrogen are that it is colourless, odourless and is chemically inert and boils at -195.8°C. It is usually used for high-value products due to the high capital cost for gas compression.

Dehydro-freezing

Dehydro-freezing is a process involving dehydration followed by quick freezing. First of all, food product is removed of its 50-60 per cent of the water by evaporation before freezing. The texture and flavour of food products frozen using such process are claimed to be superior to those resulting from freezing alone, and rehydration is more rapid than with dehydrated products.

Quality loss Due to Freezing Temperatures

Freezing is done to preserve food by reducing the product temperature, thereby slowing the quality deterioration processes. But still some changes take place on long storage of frozen foods like oxidation of fat, growth of microorganisms, enzymatic reactions and loss of surface moisture (dehydration) which needs attention.

Chemical and physical changes

Many changes, both chemical and physical may take place during freezing and subsequent frozen storage. Enzymes may catalyze chemical change detrimental to the quality of the frozen food. The action of lipase is more likely to be a problem than the activity of proteases during frozen storage.

The treatment of the food prior to storage influences the extent of enzyme activity subsequently. Enzymes, which cause the loss of colour, loss of nutrients and flavour changes in frozen food especially vegetables, must be inactivated to prevent such reactions from taking place. Since fruits are not blanched, enzymes in fruits to be frozen should be controlled by using chemical compounds such as ascorbic acid (vitamin C), which interfere with deteriorative chemical reactions. Other temporary measures include soaking the fruit in dilute vinegar solutions or coating the fruit with sugar and lemon juice to control enzyme-activated browning. But these are not as effective as ascorbic acid.

Oxidative rancidity may develop in frozen products through contact of the frozen product with air. To prevent this problem, proper packaging which does not permit air to pass into the product should be used. Physical changes include clumping of egg yolk.

Flavour changes

Flavour may be modified during frozen storage as a result of enzymatic or oxidative changes in the food. Vegetables and food containing fats are most susceptible to the detrimental changes in flavour during frozen storage. The extent of flavour modification is determined by treatment prior to freezing and by storage condition during storage. Vegetables need to be blanched prior to being frozen to aid in minimizing flavour changes. Blanching helps to inactivate lipoxidase, the enzyme which causes development of rancidity in fats in vegetables. Damage to vegetables results in development of off flavours if these vegetables are held for a storage period prior to processing.

Textural changes

Texture of frozen foods is modified by the freezing process. Whether the change is desirable or not will depend on the food itself. When the water freezes, it expands and the ice crystals cause the cell walls to rupture. As a result, the texture of the produce after thawing will be markedly much softer than it was when raw. Therefore, frozen foods to be eaten should be partially thawed. Textural changes due to freezing are less noticeable in high starch vegetables, such as peas and corn etc.

Colour changes

Pigment changes can be noted in frozen beef. The iron in the myoglobin can undergo an oxidative reaction to form metmyoglobin, a reddish brown pigment with less visual appearance than the original myoglobin or oxymyoglobin. Some of the reddish fruits and vegetables become less attractive during frozen storage because the loss of some of their anthocyanin pigments into the medium surrounding them. In peaches, enzymatic action can produce colour changes in storage. The polyphenol oxidase enzyme in peaches catalyses a chemical change of the flavonoid pigments with molecular oxygen resulting in formation of quinones which in turn are converted to brown coloured polymers yielding a familiar brownish colour of frozen peaches.

Moisture loss

Fast cooling and freezing can prevent moisture loss or dehydration by minimizing the water evaporation rate and time.

Freezer burn

The grainy, brownish spot formed where the tissues become dry and tough in frozen storage is known as freezer burn. This imparts off flavours to the product. Freezer burn can be prevented by using thick moisture proof packaging.

Nutritional value of frozen foods

Freezing, when properly done, may potentially preserve the greatest quantity of nutrients. Nutritional merits of frozen foods are influenced by the preparation required prior to freezing. Blanching is necessary to inactivate enzymes but it also destroys Vitamin C to the extent ranges of 40 per cent. B-vitamins are also destroyed. Water soluble vitamins are lost in the drip while thawing frozen meats. This loss ranges between 3-10 per cent.

PRESERVATION BY CHEMICAL PRESERVATIVES

Introduction

Chemical preservation of perishable foods by various additives or preservatives is a significant part of the food preservation industry which is used in combination with other forms of preservation like freezing, canning, dehydration etc. Chemically preserved food products like squashes and crushes etc. can be kept for a fairly long time even after opening the seal of the bottle. It is however essential that the use of chemicals is properly controlled as their indiscriminate use is likely to be harmful. These should be added in very low quantities so that organoleptic and physico-chemical properties of the foods are not altered at all or only a little.

Preservation Principle

Food preservatives interfere with the mechanism of cell division, permeability of cell membrane and activity of enzymes and inhibit the spoilage factors. These work either as direct microbial poisons or by reducing the pH to a level of acidity that prevents the growth of microorganisms.

Definition of Food Preservative

Preservatives are the chemical agents which serve to retard, hinder or mask undesirable changes in food. More precisely, preservatives are substances when added to food to retard, inhibit or arrest the activity of microorganisms such as fermentation, acidification and decomposition of food or of masking any of the evidence of putrefaction but it does not include salt, sugar, vinegar, glycerol, alcohol, spices, essential oils etc.

According to Prevention of Food Adulteration (PFA) Act (1954) and Food Standards and Safety Act (FSSA) of 2006, a 'preservative' means a substance which when added to food, is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food.

Preservatives may be anti-microbialpreservatives, which inhibit the growth of bacteria and fungi, or antioxidantssuch as oxygen absorbers, which inhibit the oxidation of food constituents. Common anti-microbial preservatives include calcium propionate, sodium nitrate, sodium nitrite and sulfites (sulfur dioxide, sodium bisulphite, potassium hydrogen sulphite, etc.) and ethylenediamine tetraacetic acid (EDTA). Antioxidants include butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT).

Sulphur dioxide (including sulphites) and benzoic acid (including benzoates) are among the principle preservatives used in the food processing industry.

Classes of preservatives

Under PFA (1954) and FSSA (2006), preservatives are classified into two classes Class I and Class II preservatives

Class I preservatives include mainly natural products which are used comparatively in higher concentrations than class II preservatives. There is no restriction to the addition of Class I preservatives to any food. For example- common salt, sugar, dextrose, spices, vinegar or acetic acid, honey, vegetable oils etc.

Class II preservatives are generally synthetic chemicals used in small quantities. Use of more than one class II preservatives is prohibited. For instance- benzoic acid and its salts, sulphur dioxide and the salts of sulphurous acid, nitrites and nitrates, sorbic acid and its salts, propionic acid and its salts, lactic acid and its salts, methyl or propyl parahydroxy benzoic acid, sodium diacetate are used.

The permitted usage levels of various chemical preservatives in different preserved food products are given in Table 1.

Table 1. Permitted usage levels of chemical preservatives in foods

Chemical preservative	Concentration (ppm)	Foods
Sorbic acid and its salts (calculated as sorbic acid)	50	Nectars, ready to serve beverages in bottles/pouches selling through dispenser
	100	Fruit juice concentrates with preservatives for conversion in juices, nectars for ready to

		serve beverages in bottles/ pouches selling through dispensers
	200	Fruit juices (tin , bottles or pouches)
	500	Jams, jellies, marmalades, preserve, crystallized glazed or candied fruits including candied peels fruit bars
Benzoic acid and its salts	120	Ready to serve beverages
	200	Jam , marmalade, preserve canned cherry and fruit jelly
	250	Pickles and chutneys made from fruits or vegetables
	600	Squashes, crushes fruit syrups, cordials, fruit juices and barley water or to be used after dilution; Syrups and sherbets
	750	Tomato and other sauces; Tomato puree and paste
Sulphur dioxide	40	Jam , marmalade, preserve canned cherry and fruit jelly
	150	Crystallized glace or cured fruit (including candied peel)
	350	Squashes, crushes fruit syrups, cordials, fruit juices and barley water or to be used after dilution; Syrups and sherbets; Fruit and fruit pulp
	2000	Dehydrated vegetables
Sodium and/ or Potassium nitrite expressed as Sodium nitrite	200	Pickled meat

Lactic acid	No limit	Fermented meat, dairy and vegetable products, sauces and dressings, drinks.
Citric acid	No limit	Fruit juices; jams; other sugar preserves
Acetic acid	No limit	Vegetable pickles; other vegetable sauces, chutney

Source: FSSA (2006) and Garg et al. (2010)

Benzoic Acid and Related Compounds

Sodium benzoate was the first chemical preservative permitted in foods by the FDA, and it continues to be widely used in large number of foods. Benzoic acid and its related compounds possess antimicrobial activity and their antibacterial action increases in the presence of CO2 and acid. For example- Bacillus subtilis cannot survive in benzoic acid solution in the presence of CO2.

As used in acidic foods, these act essentially as a mold and yeast inhibitor. In fact, benzoic acid is more effective against yeasts than against molds. It does not stop lactic acid and acetic acid fermentation. Benzoates have greatest activity at low pH especially in food products with pH below 4.5. Optimum functionality occurs between 2.5 and 4.0 pH. Benzoic acid is mostly used in coloured products of tomato, phalsa, jamun, pomegranate, strawberry, coloured grapes etc. as in the long run, it may darken the product.

Sodium benzoate, sodium salt of benzoic acid, is very effective as it is nearly 180 times more soluble in water than benzoic acid. It produces benzoic acid when dissolved in water. It should be used at low levels to avoid possible off-flavors in some products. The maximum level allowable by PFA act is 0.075 per cent. It is used in fruit products, jams, relishes, beverages etc. and is effective against yeasts, some bacteria (food borne pathogens but not spoilage bacteria) and some molds.

Sorbic acid and related compounds

Sorbic acid and related compounds have antimicrobial properties. They are available as sorbic acid, potassium sorbate, sodium sorbate or calcium sorbate. Salts of sorbic acid are used in many cases as they are highly soluble in water and produce sorbic acid when dissolved in water. The potassium salt of sorbic acid i.e. potassium sorbate is much more soluble in water than the acid. It does not impart any noticeable flavour at normal usage concentrations. Maximum level allowable by PFA act is 0.3 per cent. It is effective up to pH 6.5 but effectiveness increases as the pH decreases. It has about 74 per cent of the antimicrobial activity of the sorbic acid, thus it is required in higher concentrations than pure sorbic acid. It is effective against yeasts, molds, and select bacteria, and is widely used at 0.025 to 0.10 per cent levels in cheese, beverages, fermented and acidified vegetables, smoked and salted fish. In wine processing, sorbates are used to prevent refermentation.

Propionic Acid and Related Compounds

Propionic acid is inhibiting mould and rope bacteria growth but negligible effect on yeast. Propionic acid and its salts, sodium and calcium propionates, are approved by USFDA as GRAS (Generally Recognized As Safe) substances for food use and also by PFA act in India. Propionates are effective up to maximum limit of 5.5 pH. They are used in preserving cheese, non-alcoholic beverages, jams and jellies. Typical usage level of propionic acid and propionates is 0.2 per cent.

Parabens

The parabens are alkyl esters of para-hydroxy benzoic acid. The two most common esters are methyl and propyl parabens approved by USFDA as GRAS. PFA act has mentioned it among the class II preservatives. The maximum concentration allowed is 0.1 per cent. They are most active against yeasts and moulds (0.5-0.1 per cent) but ineffective against bacteria, especially gram negative bacteria.

Solubility of parabens increases with increase in temperature of water. Methyl paraben is more soluble in water but less effective against moulds than propyl paraben. Therefore, a mixture of methyl paraben (2 to 3 parts) with propyl paraben (1 part) is normally used to negate the difference in their solubility.

Parabens are effective at higher pH values from 3 to 8 and also stable at low and high temperatures, even up to steam sterilization. But they are not as widely used due to high cost and objectionable flavour. They are used in beverages, jams, jellies, preserves, smoked fish and pickles.

Lactic acid

Lactic acid is formed by microbial fermentation of sugars in preserved food products such as sauerkraut and pickles. The acid produced decreases the pH to levels unfavourable for growth of spoilage organisms such as putrefactive anaerobes and butyric-acid-producing bacteria. It does not control yeasts and mould growth, which can grow at such pH levels. Inclusion of other preservatives such as sorbate and benzoate may be used in that case.

Acetic acid

It is also known as vinegar. Acetic acid is a general preservative inhibiting many species of bacteria, yeasts and to a lesser extent moulds. It is also a product of the lactic-acid fermentation. It is more effective in preservative action than lactic acid at same pH levels. It is mainly used in products such as pickles, sauces and ketchup.

Sulphur dioxide and sulphites

Sulphur dioxide and its derivatives have been widely used in foods as a food preservative. It serves both as an antioxidant and reducing agent and prevents enzymatic and non-enzymatic reactions, leading to microbial stability. The common used forms are sulphur dioxide gas and sodium, potassium and calcium salts of sulphite, bisulphite or metabisulphite, which are powders. Various sulphite forms dissolve in water and yield 50 to 68 per cent sulphur dioxide gas. It has bactericidal and bacteriostatic properties and is more effective against bacteria especially gram negative bacteria than moulds and yeasts.

Sulphur dioxide gas (SO2) is one of the oldest known fumigant and a wine preservative. The gaseous form is produced either by burning sulphur or by its release from the compressed liquefied form. It is a colourless, suffocating, pungent-smelling, non-flammable gas and highly soluble in cold water.

Sulphites are effective in producing more SO2 ions at pH values less than 4.0. Metabisulphite are more stable to oxidation than bisulphites and the latter show greater stability than sulphites.

Sulphites inhibit microbial growth by reacting with the energy rich compound like adenosine triphosphate; inhibiting some metabolic pathways; and blocking cellular transport systems. Sulphur dioxide also inhibits browning, both enzymatic and nonenzymatic, reactions in fruits and prevents darkening of colour and alterations of flavour. Therefore, sulphites are used to prevent or reduce discolouration of light-coloured fruits and vegetables, such as dried apples and dehydrated potatoes. These are added to sun-dried tomatoes, dried apricots, dried potatoes and lemon juice. These are also commonly used to lengthen the life of fruit juices.

They are also used in wine-making because they inhibit only bacterial growth but do not interfere with the desired development of yeast. Potassium metabisulphite (KMS) is generally used in non-coloured products whereas in coloured products containing anthocyanin pigment, sodium benzoate is used to prevent discolouration.

USFDA prohibits the use of sulphites in foods as it destroys thiamin (vitamin B1) and also causes severe allergic reactions, especially in asthmatics though, for the majority of the population, they are safe.

Nitrites and Nitrates

Nitrites have been used in meat curing for many centuries. It is used along with a mixture of salt, sugar, spices, and ascorbate for curing meats. Nitrite contributes to the development of the characteristic colour, flavour and texture improvement in addition to preservative effects. Sodium nitrite is quite soluble in water and is more effective below neutral pH (below 7.0). Along with salt, nitrite exhibits stronger antimicrobial action.

Nitrates break down in the body to nitrites and this stops the growth of bacteria, especially Clostridium botulinum, the bacteria that cause botulism poisoning. This is the reason nitrites and nitrates are used mainly among the packaged meats.

Nitrites also stabilize the red colour in cured meat and stop it from turning grey. Nitrates get readily converted into nitrites, which then react with the protein myoglobin to form nitric oxide myoglobin. During cooking, this is converted to nitrosohemochrome, a stable pink pigment, which impart a pink, fresh hue to cured meat. This chemical stabilizes the red colour of the meat and gives an appearance of fresh meat. That is why nitrites are a preferred preservative of meat processors even though its excess use is restricted in many countries.

Nitrite salts should be used with precaution because they can react with certain amines in food at acidic pH to produce nitrosamines, which are known to cause cancer by giving rise to compounds like nitrodimethyl-amine. Addition of sodium ascorbate inhibits nitrosamine formation and reduces the problem of nitrosamines. Nitrites and nitrates are permitted as preservatives in cured meat and meat products including poultry at levels below 200 ppm by USFDA and FSSA in India.

Antibiotics

Antibiotics are antimicrobial substances produced by microorganisms have been allowed for food use only in recent years. But they are not widely used in food preservation due to the risk of ill effects on consumer and possibility of appearance of resistant strains. However, nisin and have been permitted in some foods.

Nisin

Nisin is a polypeptide produced by Steptrococcus lactis (now called Lactococcus lactis). Its solubility depends on the pH of the medium and it is more soluble in acidic pH. Its antimicrobial action increases as the pH decreases. Nisin has a narrow spectrum affecting only gram-positive bacteria, including lactic acid bacteria, streptococci, bacilli, and clostridia. It does not inhibit gram-negative bacteria, yeasts or moulds. Nisin has been permitted in processed cheese up to 12.5 ppm under FSSA.

Natamycin

Natamycin is produced by the bacterium Streptomyces natalensis. The compound has a large lactone ring which is substituted with one or more sugar residues. Natamycin is primarily effective against yeast and moulds and is ineffective against bacteria. It has been permitted for surface treatment of hard cheese under FSSA with maximum level of application not to exceed 2mg/dm3.

Ethylenediamine Tetra Acetic Acid (EDTA)

EDTA is a metal-chelating agent which removes the metal cofactors that many enzymes need, thus preventing the food spoilage. But, it is not mentioned under FSSA as preservative.

Antioxidant preservatives

Antioxidant preservatives prevent foods from becoming rancid, browning, or developing black spots by suppressing the reaction that occurs when foods combine with oxygen in the presence of light, heat, and some metals. Antioxidants also minimize the damage to some essential amino acids and loss of some vitamins.

Antioxidant preservatives, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tert-butylhydroquinone (TBHQ), and propyl gallate (PG), stop the chemical breakdown of food that happens in the presence of oxygen by inhibiting the free radicals that help initiate and propagate these reactions.

FOOD IRRADIATION

Introduction

Food irradiation is a physical process of subjecting foods to short wave radiation energy in order to preserve them by sterilization, disinfestation or disinfection. Irradiation is considered a more effective and appropriate technology to destroy food borne pathogens as compared to heat or chemical preservation.

What is food irradiation?

Food irradiation is the process of exposing food to controlled levels of ionizing radiation to kill harmful bacteria, pests, or parasites, or to preserve its freshness. It is also called cold pasteurization as it kills harmful bacteria without heat.

Mode of Action

Irradiation can directly impair critical cell functions or components like DNA and indirectly form radiolytic products/ free radicals from water, which are responsible for 90 per cent of DNA damage. Irradiation results in a variety of changes in living cells based on the dosage. For example- high doses kill microbes/ insects; low doses destroy some of the enzymes that lead to fruit ripening, thereby, delaying it and it also interfere with cell division, thereby limiting/ preventing the reproduction of microbes, insects, parasites, etc.

Radiation in Food Preservation

Ionizing radiation is the radiation with enough energy to remove electron(s) from atoms and molecules and to convert them to electrically-charged particles called ions. But, at dose levels approved for food irradiation, these radiations cannot penetrate nuclei and thus, food can never become radioactive. Other types of radiation energy i.e. infrared and microwaves are non-ionizing radiations with longer wavelengths. Infrared radiation is used in conventional cooking. Microwaves, due to their relatively longer wavelength, have lower energy levels but are strong enough to move molecules and generate heat through friction. Three types of ionizing radiations are approved to be used for food irradiation.

- Electron beams generated from machine sources operate at a maximum energy of 10 million electron volts (MeV).
- X-rays generated from machine sources operate at a maximum energy of 5 MeV.
- Gamma rays are emitted from Co-60 or Ce-137 with respective energies of 1.33 and 0.67 MeV.

Electron beams

Electron beams are the streams of very fast moving electrons produced in electron accelerators. Electron beams have a selective application in food irradiation as they can penetrate only one and one half inches deep into the food commodity. Due to poor penetration, shipping cartons (pre-packed bulk food commodities) are not irradiated with electron beams. Electron beams can be switched on or off at will and require shielding as they are generated through machine sources.

X-rays

Just like electron beams, X-rays are also generated through machine sources. X-rays are photons and have much better penetration and are able to penetrate through whole cartons of food products. X-rays also can be switched on or off at will and therefore, require shielding.

Gamma rays

Gamma rays are produced from radioisotopes either Cobalt-60 (Co-60) or Cesium-137 (Ce-137). Contrary to electron beams and X-rays, radioisotopes cannot be switched off or on at will and they keep on emitting gamma rays, therefore radioisotopes require shielding. Co-60 source is kept immersed under water when it is not in use and Ce-137 is shielded in lead. Due to their continuous operation, radioisotopes need to be replenished from time to time. Gamma rays are photons and have deep penetration ability.

Units of irradiation

Radiation dose is the quantity of radiation energy absorbed by the food as it passes through the radiation field during processing. The gray (Gy) is the unit used to measure absorbed dose of radiation and is equal to one joule of energy absorbed per kg of matter being irradiated.

1 Gy (Gray) = 100 rad (radiation absorbed dose)

1 Kilogray (kGy) = 1000 Gy

International health and safety authorities have endorsed the safety of irradiation for all foods up to a dose level of 10 kGy. Recent evaluation of an international expert study group appointed by Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) showed that food treated according to good manufacturing practices (GMPs) at any dose above 10 kGy is also safe for consumption, making irradiation parallel to heat treatment of food.

In India, the Ministry of Health and Family Welfare amended the Prevention of Food Adulteration Rules (1954) through a Gazette notification dated August 9, 1994, permitting irradiation of onion, potato and spices for internal marketing and consumption. In 1998 a number of other food items were permitted for radiation processing . Approval for additional items like fresh, frozen and dried sea foods and pulses have been given under FSSA regulations (2011).

Food items approved for radiation preservation under PFA Rules, 1955 and FSSA regulations, 2011

Name of food	Purpose	Dose (kGy)	
		Minimum	Maximum
Onion	Sprout inhibition	0.03	0.09
Potato		0.06	0.15
Ginger, garlic and shallots (Small onion)		0.03	0.15
Mango	Disinfestation	0.25	0.75
Rice		0.25	1.00
Semolina (sooji, rawa), wheat atta and maida		0.25	1.0
Raisin, figs and dried dates		0.25	0.75
Meat and meat products including chicken	Shelf-life extension and pathogen control	2.5	4
Spices	Microbial decontamination	6	14
Fresh sea foods	Shelf-life extension and pathogen control	1.0	3.0
Frozen sea foods		4.0	6.0
Dried sea foods	Disinfestation	0.25	1.0

Source: http://www.barc.ernet.in/bmg/ftd/index.html and FSSA regulations (2011)

Terminology for Radiation Treatment of Foods

Radurization

Radurization process involves irradiation applied to obtain a substantial reduction in number of spoilage organisms, thereby extending the shelf life of food 3 to 4 fold. It is applied at dosage of 0.5-10 kGy. Irradiation of 5 kGy eliminates most of the spoilage organisms.

Radicidation

Radicidation aims at reducing considerable number of non-spore forming pathogenic microorganisms (other than viruses) and parasites. It is applied at dosage of 3.0-10 kGy and improves the hygienic quality of the food and also reduces the risk of public exposure to pathogens.

Radappertization

Radappertization refers to irradiation applied to prepackaged, enzyme-inactivated foods to reduce the number and/or activity of microorganisms. For example - 12D reduction in C. botulinum spores. It is applied at dosage of 25-60 kGy. The process renders the food shelf stable without refrigeration.

Applications of Radiation Processing in Food

From a practical point of view, there are three general application and dose categories that are referred to when foods are treated with ionizing radiation.

Applications of radiation processing in food

Dose level	Dose	Applications in food	
Low dose	Up to 1 kGy	Sprout inhibition in bulbs and tubers	0.03 - 0.15 kGy
		Delay of fruit ripening	0.25 - 0.75 kGy
		Insect disinfestation including quarantine treatment and elimination of food borne parasites	0.25 - 1 kGy
Medium dose	1-10 kGy	Reduction of spoilage microbes to improve shelf-life of meat, poultry and seafoods under refrigeration	1.5 - 3 kGy
		Elimination of pathogenic microbes in fresh and frozen meat, poultry and seafoods	3 - 7 kGy
		Reducing number of microorganisms in spices to improve hygienic quality	10 kGy
High dose	Above 10 kGy	Sterilization of packaged meat, poultry and their products which are shelf-stable without refrigeration	25 - 70 kGy
		Sterilization of hospital diets	25 - 70 kGy

Nutritional Quality of Irradiated Foods

Irradiation does not considerably raise the temperature of the food and nutrient losses are small and often significant as compared to other methods of preservation such as canning, drying and heat pasteurization.

Macronutrients like carbohydrates, proteins, and fats, undergo little change during irradiation even at doses over 10 kGy. Similarly, the essential amino acids, minerals, trace elements and most vitamins do not suffer significant losses.

Different types of vitamins have varied sensitivity to irradiation and it depends on the complexity of the food system and the solubility of the vitamins in water or fat. Vitamin losses can be minimized by irradiating the food in frozen form or by packaging it in an inert atmosphere such as under nitrogen. Four vitamins are recognized as being highly sensitive to irradiation: B1, C (ascorbic acid), A (retinol) and E (alpha-tocopherol). However, B1 is even more sensitive to heat than to irradiation.

Advantages and Disadvantages of Food Irradiation

Benefits	Limitations
Radiation processing does not change texture and freshness of food, unlike heat. In fact, it is difficult to distinguish between irradiated and non-irradiated food on the basis of colour, flavour, taste, aroma or appearance.	Radiation processing cannot be applied to all kinds of foods.
Radiation processing does not affect significantly nutritional value, flavour, texture and appearance of food.	Radiation processing cannot make a bad or spoiled food look good i.e. it is not a magic wand.
Radiation cannot induce any radioactivity in food and does not leave any harmful or toxic radioactive residues on foods as is the case with chemical fumigants.	It cannot destroy already present pesticides and toxins in foods.
It is a very effective method due to its highly penetrating nature of the radiation energy and can be used on packed food commodities.	Compliance of a particular food commodity to radiation processing has to be tested first in a laboratory.
Prepackaged foods can be made sterile thus improving shelf-life.	Only those foods for which specific benefits are achieved by applying appropriate doses and those duly permitted under the PFA Rules, (1955) and now FSSA regulations (2011) can be processed by radiation.
The radiation processing facilities are environment friendly and are safe to workers and public around.	--

Source: http://www.barc.ernet.in/bmg/ftd/index.html

HURDLE TECHNOLOGY

Hurdle technology foods are defined as products whose shelf life and the microbial safety are extended by use of several factors none of which individually would be totally lethal towards spoilage or pathogenic microbes (Berwel, 1994).

Potential Hurdles for Use in Preservation of Foods

Physical hurdles

High temperature (Sterilization, Pasteurization, blanching) low temperature (Chilling and freezing), U.V radiation, ionizing radiation, electromagnetic radiation (microwave energy, radio-frequency, or oscillation magnetic field pulses and high electric field pulses, photodynamic inactivation, ultrahigh pressure ultrasoniaction, packaging film (plastic, multilayer, active coating, edible coating modified atmosphere packaging, gas vaccum moderate vaccum and active packaging) aseptic packaging and food micro structure.

CONCENTRATION OF FOODS

Concentration process increases the solids content and reduces the weight and volume of a food. Latent heat is transferred from the heating medium (steam) to the food to raise the temperature of its boiling point during evaporation. The vapour pressure rises and bubbles of vapour in the liquid are formed due to latent heat of vaporization supplied by the steam. The vapour is then removed from the surface of the boiling liquid. The more common concentrated foods include evaporated and sweetened condensed milks, fruits and vegetable juices and nectars, sugar syrups and flavoured syrups, jams and jellies, tomato paste etc.

Methods of Concentration

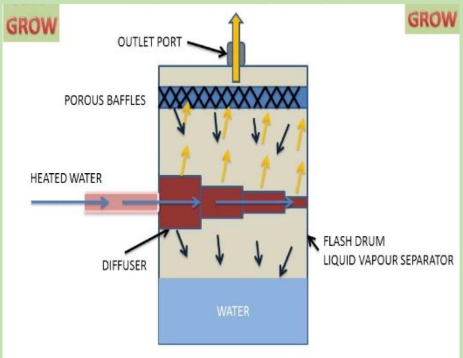
Solar evaporation

Solar evaporation is the simplest method of evaporating water with solar energy. This process was used in earlier times to obtain salt from sea water and still it is practiced. However, the process is very slow and is suitable only for concentrating salt solutions.

Open kettles

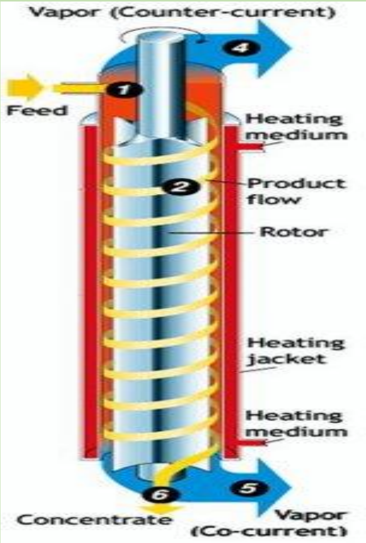
Only some foods can be satisfactorily concentrated in open kettle that is heated by steam e.g. in case of jellies and jams and for certain types of soups. However, high temperatures and long concentration times damage most foods. In addition, thickening and burning of product to the kettle wall gradually lowers the efficiency of heat transfer and slows the concentration process. This method is apt for caramelized colour and typical flavour development in foods high in sugar.

Concentration by flash evaporation



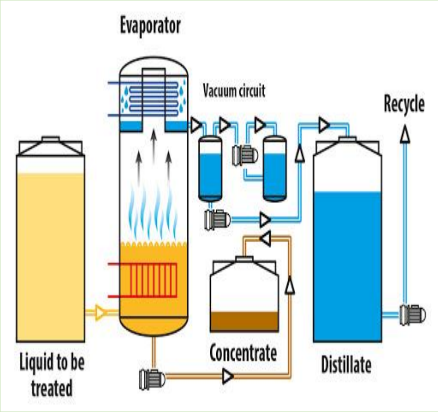
Concentration process is markedly speeded when sub sized food material is brought in direct contact with heating medium. This is done in flash evaporators. Clean steam superheated at about 150°C is injected into food and then is pumped into an evaporation tube where boiling occurs. The boiling mixture then enters a separator vessel and the concentrated food is drawn off at the bottom and the steam plus water vapour from the food is evacuated through a separate outlet. Foods lose volatile flavour constituent because of high temperature.

Concentration by thin film evaporation



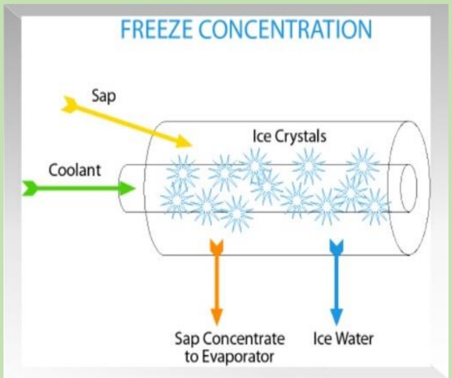
In thin film evaporators, food is pumped into a vertical cylinder which has a rotating element that spreads the food into a thin layer on a cylinder wall. The cylinder wall of double jacket construction usually is heated by steam. Water is quickly evaporated from the thin food layer and the concentrated food is simultaneously wiped from the cylinder wall. The concentrated food and water vapour are continuously discharged to an external separator from which product is removed at the bottom and water vapour passes to a condenser. Product temperature may reach 85°C or higher but since residence time of the concentrating food in the heated cylinder may be less than a minute, heat damage is minimal.

Concentration by vacuum evaporation



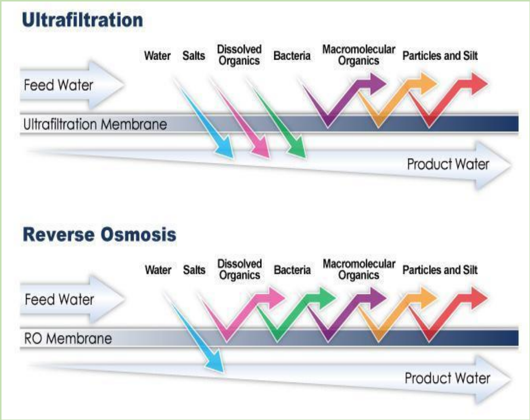
This method is suitable for heat sensitive foods as this method involves low temperature. Evaporation under vacuum can be done by operating thin film evaporators under vacuum by connecting a vacuum pump or steam ejector to the condenser. Several vacuum vessels can be attached in series so that the food product moves from one vacuum chamber to the next and thereby becomes more and more concentrated at each step. The consecutive vessels are maintained at progressively higher degrees of vacuum and hot water vapour arising from first step is used to heat the second vessel and so on. In this way heat energy is efficiently used.

Freeze concentration



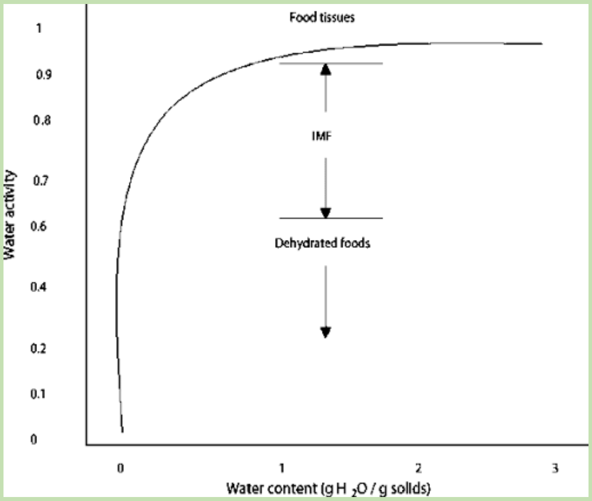
Initially formed ice crystals during freezing process are removed with the help of centrifugal force resulting in a concentrated unfrozen food which passes through a fine mesh screen. This process is repeated many times to reach final concentration of food.

Ultrafiltration and reverse osmosis



These are the two methods of concentrating foods employing pressure driven membrane separation process. In ultrafiltration large solute particles are selectively removed whereas in reverse osmosis smaller solutes are separated out.

Intermediate moisture foods (IMF)



Intermediate moisture foods are those in which the moisture content is reduced to a level low enough to prevent spoilage microorganisms from growing but moist enough for the food to have improved palatability characteristics. Intermediate moisture foods or semi-moist foods contain 20-50 per cent. In addition, they contain high concentration of dissolved solutes. These foods do not require refrigeration during storage and can be eaten without rehydration. Honey, jam, jelly, cakes, dates and osmo-dried food products are the examples of intermediate moisture foods.

RECENT METHODS IN PRESERVATION

NATURAL PRESERVATIVES TO IMPROVE FOOD QUALITY AND SAFETY

Microbial food spoilage is an area of immense concern for the food industry. It is estimated that as much as 25% of all food produced is lost after harvest due to microbial activity. While the growth of spoilage microbiota in foods is not harmful for the human health, it has negative impact on the shelf-life, textural characteristics, and overall quality of the finished products, affects the consumer choices, and results in significant commercial losses. Thus, prevention or inhibition of microbial growth in foods is of outmost importance for the current globalized food production. Hence, there is still the need for new processing methods, to be used either alone or in combination with the already existing ones, able to reduce or eliminate foodborne pathogens and spoilage bacteria.

Chemical additives have been extensively used to prevent the survival and proliferation of microorganisms, but their safety and impact on human health are under discussion. Since the reduction or elimination of pathogens and spoilage microorganisms in food is the foremost priority, the current trends in food processing are focusing on the use of natural compounds, which are considered as safe alternatives and satisfy the consumer preferences for more “green foods.” Hence the increased awareness on the safety of food additives and preservatives, and the consumer’s trend to avoid foods containing chemicals, which, in the long-term, may have adverse impact on their health, have generated a significant number of studies and publications on the potential use of various natural substances, recognized as GRAS (Generally Recognized as Safe), to be used as food preservatives.

Chemical compounds added to foods as antioxidant agents are also of concern, particularly when important protein sources (e.g., burgers, steaks) are involved in the daily diet of westernized consumer living in the developed countries. Synthetic antioxidants such as BHT, TBHQ, and BHA have demonstrated various adverse effects on the human health including allergy, headache, asthma, and dermatitis. Recent studies on the utilization of natural antioxidants (e.g., herbal essential oils and extracts) indicate their capacity and safety.

Also, the antimicrobial properties of natural substances such as plant essential oils and extracts have been extensively studied with promising results. The proper recycling and use of fruit-processing plants by-products like fruit seeds or skins discarded and piling up in huge amounts every year, are of great interest for the food industry, particularly their potential to be a useful source of oil and meal. Additionally, the oil from plant seeds can be used by the food industry for manufacturing more “natural” or “green” foods and also can sufficiently extend the shelf-life of the food product. The oils derived from fruit seeds oils may also have some more useful properties beyond being just “edible.” The oil derived from the seed extract of two Mexican varieties of cactus pear (Opuntia albicarpa and Opuntia ficus indica) has been found to have sufficient antioxidant and antimicrobial properties.

Furthermore, some biological active compounds produced by microorganisms are widely used in the food industry as well. A good alternative to conventional chemically synthesized food preservatives is the use of natural antimicrobials such as bacteriocins produced by lactic acid bacteria (LAB), with Nisin being officially employed by the food industry and thus the most widely used. Bacteriocins are peptides, actually microbial toxins, produced from various microorganisms, and so far some of them (e.g., enterocins produced mostly by enterococci) have shown remarkable antimicrobial potential and their application as a natural barrier against pathogens and food spoilage has been proven to be very efficient, when used in the form of purified or semipurified extracts or as protective cultures.

Therefore, as the developments in food preservation are focusing on the implementation of natural antimicrobials and antioxidants, the potential of alternatives to currently used preservatives aim to address recent advancements in the field of natural food preservatives and antioxidants. The prospect to replace synthetic preservatives with natural substances has been demonstrated by comparing the effects of Shirazi thyme, cinnamon, and rosemary extracts (denoted as natural antioxidants) with those of the synthetic antioxidant BHT on protein and lipid oxidations, physicochemical, microbial, and sensory characteristics of frozen beef burgers during storage. Specifically, the oxidative stability of the beef burgers containing Shirazi thyme, cinnamon, and rosemary extracts was well demonstrated, and the antibacterial activity was documented, as the total microbial counts of the tested burgers were well below the maximum allowed limit.

In conclusion, the recent advancements related to the antimicrobial and antioxidant properties of natural substances that are of interest for the contemporary food industry. Their prospective use in the food production has the potential to lead towards the production of safer and healthier foods, not excluding their contribution to a more efficient preservation of the environment, when chemicals will be replaced with natural substances.

UNIT 6

EFFECT OF FOOD PROCESSING AND PRESERVATION ON THE NUTRITIVE VALUE OF FOODS

Nutritional Effects of Food Processing

Nearly every food preparation process reduces the amount of nutrients in food. In particular, processes that expose foods to high levels of heat, light, and/or oxygen cause the greatest nutrient loss. Nutrients can also be "washed out" of foods by fluids that are introduced during a cooking process. For example, boiling a potato can cause much of the potato's B and C vitamins to migrate to the boiling water. You'll still benefit from those nutrients if you consume the liquid (i.e. if the potato and water are being turned into potato soup), but not if you throw away the liquid. Similar losses also occur when you broil, roast, or fry in oil, and then drain off the drippings. The table below compares the typical maximum nutrient losses for common food processing methods. This table is included as a general guide only. Actual losses will depend on many different factors, including type of food and cooking time and temperature.

Typical Maximum Nutrient Losses (as compared to raw food)					
Vitamins	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Vitamin A	5%	50%	25%	35%	10%
Retinol Activity Equivalent	5%	50%	25%	35%	10%
Alpha Carotene	5%	50%	25%	35%	10%
Beta Carotene	5%	50%	25%	35%	10%
Beta Cryptoxanthin	5%	50%	25%	35%	10%
Lycopene	5%	50%	25%	35%	10%
Lutein+Zeaxanthin	5%	50%	25%	35%	10%
Vitamin C	30%	80%	50%	75%	50%
Thiamin	5%	30%	55%	70%	40%
Riboflavin	0%	10%	25%	45%	5%
Niacin	0%	10%	40%	55%	5%
Vitamin B6	0%	10%	50%	65%	45%
Folate	5%	50%	70%	75%	30%
Food Folate	5%	50%	70%	75%	30%
Folic Acid	5%	50%	70%	75%	30%
Vitamin B12	0%	0%	45%	50%	45%
Minerals	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Calcium	5%	0%	20%	25%	0%
Iron	0%	0%	35%	40%	0%
Magnesium	0%	0%	25%	40%	0%
Phosphorus	0%	0%	25%	35%	0%
Potassium	10%	0%	30%	70%	0%
Sodium	0%	0%	25%	55%	0%
Zinc	0%	0%	25%	25%	0%
Copper	10%	0%	40%	45%	0%

PROCESSING CAN AFFECT THE NUTRIENT CONTENT OF FOOD

There are many different forms of processing to which food may be subjected before we eat it. All of these processes have some effect on the nutrient content. Although foods are often compared before and after processing, a better comparison is at the stage when the food is eaten. For example, during the freezing of peas there is about a 10 per cent loss of vitamin C. But because they require a shorter cooking time than fresh peas, there is virtually no difference between the vitamin C content of fresh and frozen peas as they appear on our plate.

The nutritional changes that occur in the commercial preparation of food do not differ much from those in the same food prepared in the home. Both types of food preparation involve some form of processing. There may be differences in palatability and the food manufacturer may use cheaper ingredients such as emulsifiers, cereal fillers and synthetic flavours. This may be partially off-set by the fresher foods usually available to the manufacturer. The effect of the different types of processing on nutrients is discussed below.

Use of fertilizers

The use of fertilizers containing nitrogen can result in a small increase in protein content of some foods. But the amount of vitamin C is usually decreased, probably because of the increased growth of the fruit or vegetable.

Since plant roots absorb nutrients in an inorganic form there is no nutritional difference between plants that have been organically fertilized and those fertilized using conventional fertilizers. The nutrients provided by both kinds of fertilizer are effectively the same.

Milling

During the milling of cereals, part of the original grain is removed. Depending on the extent of the milling process there are large losses of fat, dietary fibre, vitamins B-l, B-2 and niacin, and elements (minerals). Foods made from wholemeal flour are better sources of these nutrients than those prepared from white flour.

Controlled atmosphere (CA) storage and ripening, and waxing

This is a procedure for storing fruits and vegetables, particularly apples, under an atmosphere that differs from air. Its aim is to increase the storage life of the foods. The most important dietary component of apples is dietary fibre, which is unlikely to be changed appreciably during CA storage. Significant nutritional changes in other fruits and vegetables would not be expected. For the uniform ripening of some fruits, most notably tomatoes and bananas, brief storage under a 'ripening gas' can be used. This can initiate ripening or speed up the process. Fruit produced for market in this way is unlikely to be significantly different in nutrient composition compared with fruit that has matured normally, although it may taste differently. Without CA storage many seasonal fruits would not be available throughout the year.

Many fruits and vegetables have a natural coating of wax, which is removed when these foods are cleaned before appearing on the supermarket shelf. To make them shiny and attractive and promote their sale, some fruits and vegetables are artificially waxed. The waxes are dispersed in water and coated over the food to provide a thin film of wax, which gives a glossy appearance. Apples coated this way are likely to sell more readily. In addition to this cosmetic effect, the wax coating for a short time slows the loss of moisture, which causes weight loss and wilting. The nutritional advantage of waxing, if any, would be expected to be only very small. At present there is no reason to believe that the use of waxes approved for this purpose is hazardous to health.

Cutting, trimming and peeling

Trimming, peeling and cutting, used to remove inedible or undesirable portions from food, will obviously lead to nutrient loss. There is often a higher concentration of some nutrients in the outer portions of fruits and vegetables. Discarding the outer leaves of vegetables such as cabbage, spinach and lettuce and peeling fruits and vegetables such as apples, peaches, pears, potatoes and carrots, lead to a disproportionate loss of many vitamins. These foods still remain nutritious, but there would be greater benefit if they were eaten intact. It is wise to discard the outer parts only if they are inedible, limp or too difficult to clean. Removal of the stalk does not have a significant effect on nutrient content.

Trimming the fat from meat can be beneficial in reducing energy intake as well as decreasing the amount of saturated fat in the diet.

Blanching

Blanching is the heating of fruit or vegetables for a short time with either steam or water, and is an essential step before canning, drying or freezing of food.

This heating process is not meant to cook the food but to inactivate substances that would otherwise adversely affect the nutrient content, colour, flavour or texture during subsequent processing and storage.

Varying amounts of nutrients are lost in this process, in particular the water-soluble vitamins B-l, B-2, C, niacin and folacin.

Cooking - Cooking can be both detrimental and beneficial to the nutrient content of food.

Beneficial effects of cooking

Cooking is important in food processing. Although cooking results in the loss of some nutrients, it can also convert other nutrients into a form that would otherwise not be used by our bodies. Cooking also produces the desired texture, flavour and palatability we want in our food.

Starchy foods such as potatoes, corn, beans, and lentils are made more digestible by cooking. The nutritive value of the protein in legumes such as soya beans, lima beans, lentils and chick peas is also improved by cooking. Heating these foods destroys substances that would otherwise interfere with the digestibility of the protein. Adequate cooking of the foods is particularly important when they comprise the main source of protein. Other substances in soya beans, kidney beans and lentils can produce toxic effects unless cooked prior to eating. Egg whites and some fish, unless cooked, are not an effective source of the vitamins biotin and vitamin B-1 respectively. Heating flour during baking increases the amount of niacin that can be utilized by the body.

Cooking is also necessary to ensure that food is free from harmful levels of micro-organisms. As well as causing undesirable flavours and odours in food these organisms can sometimes lead to illness.

Nutrient loss during cooking

Losses of protein and carbohydrate during cooking are generally small. The amount of fat in food may be either reduced or increased depending on the method of cooking. Generally, grilling will lower the fat content and frying will increase it. The smaller the size of the pieces being fried, the greater the amount of fat that will be absorbed per 100 grams. The largest vitamin loss during cooking is usually due to destruction of vitamin C, and to a lesser extent vitamin B-1 and the other water-soluble vitamins.

Pressure cooking

Pressure cooking involves cooking at higher temperatures for shorter times compared with normal boiling. Because the vegetables are in contact with steam rather than boiling water, less of the water-soluble vitamins dissolve in the cooking water. Generally, pressure cooking will retain more nutrients than normal boiling. However, food steamed or boiled in a small amount of water in a tightly covered saucepan is likely to be as nutritious as food cooked in a pressure cooker.

Microwave ovens

Microwave cooking is much quicker than conventional cooking. The microwaves preferentially heat the water in food so that the cooking process is essentially similar to that of steam cooking. With meat, the differences in vitamin B-l and vitamin B-2 retention between microwave cooking and conventional grilling or roasting are small. With vegetables, the vitamin C in microwave-cooked food is similar to that achieved by cooking with steam or using a small amount of water in a tightly covered saucepan. Generally, microwave cooking retains nutrients as well as conventional methods.

Freezing

The major nutrient losses that occur in frozen foods are not due to freezing as such but due to the blanching that occurs before freezing, and then during subsequent thawing and cooking. In general, these losses are not greatly different from those incurred following purchase of 'market fresh' food and cooking it. The quality of some frozen fruits and vegetables is often superior to so-called 'fresh' produce, as they can be frozen very soon after being harvested.

It is important that frozen foods are stored at -18"C to prevent their rapid deterioration. If this temperature is not maintained then some nutrient losses will occur, which are not regained by refreezing.

Dehydration

Dehydration or the drying of foods is a method of preservation. With the exceptions of vitamin C and provitamin A, the nutrient losses that occur in drying are not large.

Further losses can occur depending on how the dried food is further processed. If the food is eaten in the dried form, such as dried apricots, then the food is a concentrated source of many nutrients, including dietary fibre.

If the food is left in water to rehydrate, or is boiled, then there will be the additional normal cooking losses.

Canning

Canning involves heating food in a closed container to ensure that the micro-organisms present in the raw food can no longer cause deterioration of the food or be hazardous to health. The amount of the heating depends on the type of food. Nutrient losses occur from destruction during heating and storage stages. Some nutrients, such as water-soluble vitamins and minerals, may dissolve in the water in the can, but they are lost only if this liquid is not consumed. We can reduce losses of vitamins during storage by storing the cans in a cool place.

Nutrient losses resulting from canning are generally greater than those for the same food when prepared from the fresh state in the home. However, this must be balanced against the convenience of having foods available at all times of the year no matter where we live or what the season.

Pasteurization

The main pasteurized foods that contribute significant nutrients are milk and some fruit juices. Pasteurization involves heating food for a short time to kill harmful micro-organisms that are present in the food. Not all micro-organisms are destroyed, and spoilage of the food may still occur on storage, but this can be delayed by refrigeration.

Nutrient losses during pasteurization of milk and fruit juices are generally small, and in the case of fruit juices they must contain not less than a specified minimum amount of vitamin C. This generally means that vitamin C is added by the processor to make up for any losses that occurred during processing. To minimize further nutrient losses, milk and fruit juices should be stored away from light and in a cool place.

Toasting

A loss of about 10 to 30 per cent of the vitamin B-1 present in bread occurs on toasting.

Sprouting

The consumption of seed sprouts such as beans and peas is quite widespread, particularly in China, India and Egypt.

Sprouted seeds require much shorter cooking time than the dry seeds. In addition, there is an increase in the vitamin C content and also in some B-group vitamins.

Grilling Meats

Outdoor grilling is a popular cooking method, primarily because of the wonderful taste it imparts on meats. It can also be a healthy alternative to other cooking methods, because some of the meat's saturated fat content is reduced by the grilling process. However, grilling also presents a health risk. Two separate types of carcinogenic compounds are produced by high-temperature grilling:

- **heterocyclic amines (HCAs)**

HCAs form when a meat is directly exposed to a flame or very high-temperature surface. The creatine-rich meat juices react with the heat to form various HCAs, including amino-imidazo-quinolines, amino-imidazo-quinoxalines, amino-imidazo-pyridines, and aminocarbolines. HCAs have been shown to cause DNA mutation, and may be a factor in the development of certain cancers.

- **polycyclic aromatic hydrocarbons (PAHs)**

PAHs form in smoke that's produced when fat from the meat ignites or drips on the hot coals of the grill. Various PAHs present in the resulting smoke, including benzo[a]pyrene and dibenzo[a,h]anthracene, adhere to the outside surface of the grilled meat. PAH exposure is also believed to be linked to certain cancers.

HCA and PAH content in meats can be dramatically reduced by slight alterations in your grilling method. In particular, the following practices will reduce the amount of HCAs and PAHs formed:

1. Select leaner meats - Leaner cuts of meat are less likely to drip fat on the grill and produce PAH-laden smoke.

2. Marinate meats before grilling - Researchers have determined that marinating meat prior to grilling, even for just a few minutes, can reduce HCA formation by 90% or more. It's believed that the marinade forms a protective barrier for the meat juices that prevents the HCA reaction from occurring**.**

3. Grill at lower temperatures - Lower temperature "roasting" also greatly reduces HCA formation**.**

4. Prevent flare-ups - Flames from grill flare-ups cause the formation of both HCAs and PAHs. Keep an eye on your grill and turn meats frequently to minimize the chance of flare-ups.

5. Don't overcook meats - While it's important to cook poultry and ground meats thoroughly, be careful not to overcook any meat. Well-done or burnt meats contain higher levels of HCAs than less cooked meats. For thicker cuts of meat, use a meat thermometer to measure doneness rather than just guessing**.**

HOW TO MINIMIZE NUTRIENT WATER INPUT AND OUTPUT

- Choose fresh foods that are not over-ripe, bruised, cut or scraped.
- Store foods in a cool, dark place.
- Unless the peel or outer layer is unpalatable, damaged or contaminated, cook the food whole.
- If it is necessary to slice the raw food. then try to keep the pieces as large as possible.

- When boiling, add the raw food to the boiling water rather than to cold water.
- Use the smallest amount of water possible; it is not necessary to cover the food. Steaming is a way of cooking with a minimum amount of water.
- If possible use the cooking water for gravies, sauces or soups as it is a source of water-soluble vitamins and elements (minerals).
- Cook for the minimum time necessary to make the food palatable and safe. Once cooked, eat as soon as possible. Do not keep the food warm for long periods.
- Do not use baking soda to help keep the green colour of vegetables, as this increases loss of vitamin C.
- Do not use copper utensils. (Copper helps to destroy vitamin C.)

CONSUMING RAW FOODS

The amount of nutrient loss caused by cooking has encouraged some health-conscious consumers to eat more raw foods. In general, this is a positive step. However, cooking is also beneficial, because it kills potentially harmful microorganisms that are present in the food supply. In particular, poultry and ground meats (e.g. hamburger) should always be thoroughly cooked, and the surface of all fruits and vegetables should be carefully washed before eating.

POSITIVE EFFECTS OF FOOD PRESERVATION

Home food preservation: Some people make their own baby food and preserve it themselves at home without buying any packed baby food from outside. This is beneficial in 2 ways. The first one is that you won't need to add those harmful preservatives that comes in the already packaged food. The second one is that you save a lot when you preserve your own baby food. They can have an early expiry date but at least they will be safe for consumption.

Save up on money: One can easily save up on money by the help of food preservation. You then won't need to buy food stuffs every time you need some. Keeping some healthy food preservation or doing the same at home can help you save up some nice bucks every day.

Easy alternative in case of emergency: Suppose that you came home from work late and it is already time past the dinner time. You don't have time and the energy to get up and prepare yourself something to eat. At such a time, food preservation is there to the rescue. You can eat some of the food preserved by you at home or the ones that are available in the market. This way, at the time of emergency, food preservation does help someone fill their hunger.

Negative Effects of Food Preservation

As per the negative effects, there can be many points in this regard. These are as follows.

Unfit for health: These preserved food items are really not good for health. Stale food tends to lose its nutrition content with time when kept for a long time. Eating food which is lacking in nutritional value can cause damages to health. This is a big drawback of food preservation.

Deadly diseases such as cancer: Food preservation can cause deadly diseases such as cancer and heart attack. Since these kind of food items fall short of nutritional values, they become the cause of these deadly diseases that slowly kills a person.

Obesity: Food preservation is done with the help of food preservatives which are chemicals used to protect food. These preservatives often become the cause of obesity. Preserved food is generally addictive and people tend to eat a lot of it. This increases the amount of fat in their body that makes them obese. And obesity is nothing less than a disease.

Increased cholesterol levels: Food preservation becomes the major cause of the rise in the cholesterol levels. The increased consumption of preserved food and the food preservatives lays more stress on both the liver and the heart. They immediately add to the cholesterol levels which are responsible for strokes and other diseases. This is also one of the very negative side effect of the food preservation.

Infertility: The food preservation done and consumed may be the cause of infertility. The increased amount of food preservatives taken consist of modifies GMOs which can become the primary causes of infertility in men and women.

Harmful for the kidneys: The preserved food that lacks the proper amount of nutrition can cause a havoc on the kidneys. Since the kidneys will have to work more than enough to digest those preservatives, they can overtime start to fall back in doing their job properly**.**

Food preservation when used and done at a certain extent, can prove to be beneficial in some cases. However, increased usage of it is very injurious to health and must be avoided in all cases.

UNIT 7

TRADITIONAL METHODS OF STORAGE AND PRESERVATION, FOOD FLAVOURS, IMPORTANCE OF STORAGE OF SEMI PERISHABLE AND NON PERISHABLE FOODS

Foods need to be stored for a number of reasons like to ensure availability, cope with fluctuations, to draw advantage of bulk purpose and year round supply of seasonal items.

Classification of food Based on Perishability

Some foods have longer shelf life than others. Perishability refers to the quickness with which a food gets spoilt. Foods can be classified into three groups depending on how long they can be kept without any treatment.

Perishable foods can be kept at room temperature for only few hours or 1 or 2 days before spoiling. For example- milk and milk products, meat, fish, poultry, fruits, leafy vegetables and cooked food. These foods keep well under refrigeration at household as well as commercial level. In general, the most perishable foods contain a high level of protein or have moisture and carbohydrates in them. Special methods are used to preserve such foods. The rate of spoilage varies with the temperature, moisture and or dryness of the environment. Storage of perishable foods should be done by keeping following points in mind.

- Flesh foods like meat, chicken and fish need to be kept frozen at -60°C in a deep freeze for long term storage. These foods should not be left at room temperature for more than an hour or two. Organ meats tend to spoil faster than muscle meat. Ground meats spoil faster because of high surface area exposed to contamination.
- Eggs are best kept in a cool place or in a basket in an airy room refrigerator. Never wash eggs before storing. Store eggs with their pointed end downwards.
- Milk in boiled form can be kept at room temperature for 6 to 12 hours during winters. Inside a refrigerator milk can last 3 to 4 days or even more in closed container.
- The keeping quality of a vegetable depends upon its nature. Leafy vegetables wilt and deteriorate within minutes of buying unless they are kept wrapped in a damp cloth or inside a plastic bag in the refrigerator wherein they last for more than a day or two.
- All other vegetables keep well in a cool place with relatively high humidity in a basket covered with a damp cloth.
- Vegetables must be kept in plastic bags to prevent drying by evaporation, if stored in a refrigerator.
- Do not wash fruits before storing as they spoil faster.
- Remember not to, refrigerate bananas, pineapples, papayas and avocadoes, as these fruits undergo undesirable changes in texture and flavour at refrigerator temperature. Most other fruits keep well, when refrigerated.

Semi -perishable foods can be stored for a couple of weeks or even a month or two without any detectable signs of spoilage. Temperature and humidity of the environment again affects the shelf stability of such foods. Proper handling and storage can result in fairly long storage without spoilage. Examples are all cereal and pulse products like wheat flour, semolina, vermicelli, broken wheat, Bengal gram flour, and some fruits and vegetables like citrus fruits, aonla, apples, pumpkin, roots and tubers, yams, potatoes, onions, garlic etc. Following points should while storing semi-perishable foods.

- Processed cereal products develop an off-flavour or are infested by insects very easily if not taken care. Therefore, they should be sieved and cleaned of all such contamination, exposed to the sun for a few hours, allowed to cool and then stored in tightly covered bottles or other containers.
- Especially onions and potatoes should be stored in a cool, dry and airy place to prevent them from developing moulds or growing shoots. They are best hung up from the ceiling in a wire or plastic-mesh basket, or kept in mesh containers which permit air circulation.
- Nuts become rancid and get infested with insects very easily, therefore, they should be bought in large quantities only when storage space is available.
- Fruits like apples, oranges and semi-ripe mangoes do last for a few weeks and should be put in a basket lined and covered with paper to prevent them from drying up. They need a cool environment to last long.

Non- perishable foods will keep for months or years without spoiling unless handled and stored carelessly. Examples of such foods are all preserved food products (canned, dried, pickled etc.), whole cereal, pulse and millet grains, oil seeds, nuts, fats and oils, honey, sugar, jaggery, salt, some spices and essence. Following points should be followed while storing non-perishable foods:

- Food should be carefully cleaned i.e. free from gravel, husk and other foreign matter etc. and dried thoroughly in the sun/ drier before storage.
- Storage of foods should be done in clean containers with tight-fitting lids. Containers can be made of tin, aluminum, plastic or glass. Clay pots or gunny bags may also used in case of large quantities.
- A dry, cool and dark area should be chosen for storage of non-perishable foods.

The perishability of food dictates to a considerable extent the preservation techniques that are used to keep that food in good quality. In case of non-perishable foods, preservation techniques are dedicated to keeping out insects, rodents and other pests and keeping the foods dry to prevent it from becoming moldy. Perishable and semi-perishable foods depend a great deal on the technologies of refrigeration, drying, freezing, canning and the use of chemical preservatives to give shelf stability. These treatments can make such food commodities keep for many months or years if they are performed properly.

Definition of Food Storage

Food storage is the process in which both cooked and raw materials are stored in appropriate conditions for future use without any entry or multiplication of microorganisms.

Types of Storage

Different foods need different types of storage. There are basically two types of storage, dry and low temperature. These are further classified on the basis of storage temperature required for different foods .

1. *Dry storage* is meant for longer holding of non- and semi-perishable foods, the latter being stored for a shorter time. It is the space designed for the storage of foods usually at room temperatures ranging between 20-25°C with the relative humidity maintained at 60-65 per cent.
2. *Low temperature storage* is further divided into three types based on temperature requirement.
    - Refrigerated storage is a storage space maintained at temperature between 3 to 10°C. It is used to store perishable foods for short term say 3-5 days. Beyond this period, certain changes in foods take place due to enzymatic or microbial activity. Milk and eggs are generally stored under refrigerated storage.
    - Cold storage is one in which temperature is maintained between 0 and 3°C. Such storage spaces are also called as chill rooms. These can hold perishables over a week and in the case of fruits and vegetables, even upto a month depending upon variety and stage of maturity. Fruits and vegetables are usually stored in this type of storage.
    - Freezer storage is apt for long term storage of perishable foods and the temperature ranges from -20°C to 0°C. Pretreatments like blanching, quick cooling to freezing temperature and packing in air tight containers are necessary for successful freezing. Generally, frozen foods are kept under this type of storage.

Essential features of food Storage Areas

The proper storage of preprocessed as well as post-processed foods is a key factor in the shelf-life of the food. The essential features of any food storage areas are as follows

- It should be fit for purpose (dry store, chill, frozen etc.) i.e. it must provide proper temperatures and humidity for prolonging shelf life of foods
- The separate area could be designated for different types of food. For example raw and cooked should be stored separately.
- It should be able to provide protection from contamination/ infestation
- It should be weatherproof
- It should be able to keep out direct sunlight/ heat
- It should have suitable space and structural arrangement for providing sufficient light and ventilation.
- It should be easily cleanable.
- It should provide easy access to materials
- It should be accessible for transport of food

Basic guidelines for food storage

1. Storage area should be cleaned and disinfected on regular basis.

2. Foods to be stored should be inspected for signs of damage, spoilage or infestation before storage.
3. Wash items that need washing before storage. Cans need to be wiped prior to use.
4. Frozen items should be solidly frozen before storage.
5. Rotation of stock should be done to ensure that older materials are used up before fresh ones and finished products do not remain in storage beyond their stated shelf life. For this one can apply, any one of following rules for use.
    - FIFO (First in First Out)
    - FMFU (First Manufactured First Used)
    - LILO (Last in Last Out)
6. Each type of storage area should be separated from each other to avoid cross contamination.
7. Appropriate temperatures should be maintained depending on the type of food being stored.
8. Access to storage area should be restricted to prevent pilferage.
9. Overcrowding & over stocking of storage area should not be done as it blocks air circulation making the food to spoil fast.
10. Raw materials should be properly stored before use in preservation. Ripe fruits and vegetables should be kept in clean plastic crates in a cool area, when they are being held for preservation. Dry ingredients such as spices should be stored in dry well ventilated areas.
11. Packaged products should be placed in cartons and packed on pallets, (never directly on the floor), away from walls, to ensure effective placing of pest control baits in warehouses or holding areas.
12. Packages in storage should be checked periodically to ensure that they are still intact and any spillage detected should be removed immediately and the area should be subsequently sanitized.
13. Packaging material such as cans, jars, lids, cartons, should also be kept in clean dry areas as free as possible from dust. The outer wrapping of these should not be removed until packaging material is ready for use in processing area.
14. All stored material should be labelled and dated and raw materials/ product slated for reworking or dumping, and finished products awaiting shipment should all be segregated in designated areas.

Care & Maintenance of Storage Equipments

Storage equipments also need care and maintenance for their proper functioning. For this following points should be kept in mind.

- Refrigerator doors should have proper rubber sealing.
- Walk in / deep freezer doors should be tightly sealed.
- Air vents of storage area should be checked regulary for blockage.
- Proper stacking of packages should be done.
- Proper power supply should be ensured in the storage area.
- Proper working of equipments should be ensured.
- Proper cleaning of storage area and equiments with appropriate agents should be done regularly.
- Proper pest control measures should be adopted in storage area.

UNIT 8

PACKAGING AND PACKAGING MATERIAL

Introduction

Package is a silent salesman as it is a link between the food producer and the consumer. Food packaging is an integral part of the processing and preservation of foods and can influence many factors responsible for spoilage. Packaging can influence physical and chemical changes, including migration of chemicals into foods. The flavour, colour, texture of food as well as moisture and oxygen transfer to food is influenced by packaging. The effects of temperature changes and light can be modified by packaging materials.

Definition of Packaging

Packaging is a means of ensuring the safe delivery of a product to the ultimate consumer in a sound condition and at the minimum overall cost.

Food packaging is packaging for food which contains, protects and preserves food as well as informs about the food.

Importance of Packaging

All preserved food items require packaging so as to make the product available to the user/ consumer in desired quality and form. Packaging material protects the products in all aspects, from the point of origin until their consumption. The importance of packaging is illustrated in following points:

- An adequate packaging extends the shelf-life of the surpluses of food and allows the distribution of food to other areas resulting in more choices to consumers in terms of food availability, equitable distribution of food resources, and income to producers from their produce.
- Correct packaging prevents any wastage, such as leakage or deterioration, while transportation and distribution.
- Good packaging and presentation promote consumers to buy products.

Functions of Food Packaging

Packaging is still another food preservation method. In other words, protection of the food product is a major function of packaging. Packaging is a necessary aid for storage and distribution of food. Packaging must provide the proper environmental conditions right from the start when food is packed till its finally consumed. A good package should therefore carry out following functions:

- It should provide a barrier against dirt and other contaminants and keep the product clean.
- It should be securely closed to prevent losses or leakage.
- It should protect food against any physical and chemical damage due to air, light, insects, and rodents.

- It should serve as a material handling tool containing the desired unit amount of food within a single container and may facilitate the assembly of several such units into aggregates.
- The packages may also serve as a processing aid.
- The package design should provide protection and convenience in handling and transport during distribution and marketing
- It should help the customers to identify the food and instruct them how to use it correctly.
- It should persuade the consumer to purchase the food.
- The package may serve as convenience item for the consumer, e.g. as a drinking utensil, as well as process, storage and distribution container.
- Packaging when properly used can be cost saving device.
- Package may serve the purpose of portion controlling in certain food items.
- Certain package may facilitate dispensing of the product.

Broadly major functions of packaging are:

Protection against

- ✓ Climatic hazards e.g. relative humidity (RH), oxygen, light, heat, cold, rain.
- ✓ Biological hazards e.g. insects, bacteria and moulds, mites, rodents and birds.
- ✓ Mechanical hazards those happening during packing, storing, transportation and distribution e.g. impacts, vibrations, compressions.

Preservation: The extent of time a product could be preserved in a packaging system.

Promotion:

- ✓ Attracts the consumer towards a product.
- ✓ Cuts the cost of advertising.

Objectives of Packaging - The major objectives of packaging are:

- To preserve, protect and maintain the contents in a fit and palatable condition.
- To withstand the chosen selling and distribution method.
- To furnish a design and appearance which should be attractive to the consumer, easy to open, store and dispose off.
- To provide an economical container.
- To make it easier and safe to transport.
- To prevent or minimize losses of the product.
- To provide a convenient means for dispensing the product.

Properties of a Package

The distribution chain of packaged foods is often very long and the conditions through which they must travel are indeed difficult. The pertinent properties of a package and the environmental factors to be guarded against are given in the Table.

Package properties and associated environmental factors:

Package properties	Environmental factors
Strength	Mechanical shock
Permeability	Pressure of O_2, water vapour etc.
Light transmission	Light intensity
Thermal conductivity, reflectivity	Temperature
Porosity, penetrability	Biological agents

The protection offered by a package is determined by the nature of packaging material and by the type of package construction.

Classification of Package

Food packages can be classified as follows:

Unit pack

- Primary pack or consumer pack.
- Primary containers by definition are those which come in direct contact with the food.
- The size and number of units in a pack depends on nature of product and marketing method. Generally it contains a single unit.
- This package serves as a retail pack and thus, the package should have good eye appeal and easy to open, carry or handle.

Intermediate pack

- Secondary pack.
- Such package does not come in direct contact with food.
- Its purpose is utilization of couple of unit packs, distribution, requirement and display value.

Bulk pack

- Tertiary pack/ Master pack/ distribution pack/ transport pack.
- Just like secondary pack, this type of pack also does not in direct contact with food.
- Used for distribution of unit pack or intermediate packs.
- Care has to be taken to protect against mechanical hazards.

Inner packaging components

- These are used in transport package to provide the resistance to movement of contents during journey due to vibration.
- For example- separators used in package where glass bottles are packed; cushioning materials like thermocole, expanded polystyrene (EPS), expanded polyethylene (EPE), paper cuttings, wood wool either to protect the product against the shock hazards or act as space fillers to prevent the movement of contents during journey.

External reinforcement

- The shipping containers are further reinforced by means of either plastic straps or metal straps applied along the girth as well as the length in order to strengthen the shipping container.
- Reinforcement also helps to improve the stacking strength, avoid bursting in case of failure and increase weight carrying capacity.

Materials Used for Forming a Package

Any physical material which serves as a covering, wrap or seal for an object or material is a packaging material. Protection offered by a package is determined by the nature of the packaging materials and by the type of package construction. A great variety of material is used in packaging.

Primary packaging materials are the materials which are used to form the different types of packages whereas ancillary packaging materials are the important types of materials which have got application in packaging.

Flexible packaging

Any package capable of being readily deformed by hand, including being bent, flexed or twisted is referred to as flexible packaging. E.g. bags and bubble wrap to tubes, stand-up pouches and foam cushioning materials.

Cellulose based materials

The cellulose based packaging materials are available in two forms, i.e., paper and paper board.

Paper

Paper is defined as a matted or felted sheet usually composed of plant fiber. Paper has been commercially made from such fiber sources as rags (linen), bagasse (sugar cane), cotton, and straw. Modern paper is made almost exclusively from cellulose fiber derived from wood chips after acid or alkaline hydrolysis. Different types of paper are used in packaging namely tissue paper, coated (varnish or wax coated), butter paper, glassine paper, art paper, kraft paper, vapour phase inhibitor (VPI) paper, high gloss paper and vegetable parchment paper. Paper as a packaging material has many advantages like it can be produced in many grades and can be converted to many different forms, especially boxes or cartons; it is recyclable and biodegradable; and can be easily combined with other materials to make laminated or coated packs produced with different degrees of opacity.

Paper Board

Paperboard is a generic term covering boxboard, boxboard, cardboard, cartonboard, clipboard and corrugated or solid fibreboards . Boards are made in a similar way to paper but are thicker to protect foods from mechanical damage. According to ISO standards, material weighing more than 250 grams per square metre shall be known as paperboard. Paper with density more than 180 g per square meter (gsm) is generally termed as paper board. Different types of paper boards used are coated board, duplex board, triplex board, asphalted board, grey board, mill board, clay coated board, kraft board, chip board and straw board.

Regenerated Cellulose or Cellophane

The most common types of cellophane used for packaging are moisture-proof sealable transparent cellophane (MST); moisture-proof sealable transparent coloured cellophane (MSCT); moisture-proof sealable transparent anchored cellophane (MSAT); and moisture-proof saran coated cellophane (MXXT).

Jute or Hessian

Jute fabrics of different types, like single warp and double, are used for making the jute bags. Sometimes, the jute fabrics are also made water proof either by lamination or coating with bitumen or plastic for packaging.

Aluminum foil

Please see metal foils section.

Plastics

There are various types of polymeric materials i.e. plastics which are converted into plastic films and have got wide application in packaging. Plastics are light in weight, very strong, hygienic and non-conductive. They do not rust, rot or react with most chemicals. Some of the important polymeric materials are given in the Table 2.

Table 2. Different types of plastics used for packaging

Polyethylene :

- Low density polyethylene (LDPE)
- High density polyethylene (HDPE)
- High molecular high density polyethylene (HMHDPE)
- Linear low density polyethylene (LLDPE)
- Very linear low density polyethylene (VLLDPE)

- Copolymers like surlyn or primacor (EAA)

Polypropylene :

- Bioxially oriented poly propylene (BOPP)
- Cast poly propylene (CPP)
- Tubular quenched poly propylene (TQPP)
- Polyvinyl chloride (PVC) >
- Polyethylene terephthalate (PET)
- Polystyrene (PS)
- Poly carbonate (PC)
- Poly amide or nylon (PA)

Polyethylene:

These materials have an excellent sealability, good moisture barrier, low temperature durability mand good tear resistance. LDPE is heat sealable, odour free and shrinks when heated. It is less expensive than most films and is therefore widely used in shrink or stretch-wrapping. HDPE is stronger, thicker, less flexible and more brittle than LDPE. They are however water-proof and chemically resistant and are used instead of multi-wall paper sacks for shipping containers. Generally, polythene is used for packaging processed and fresh meats, cheese etc. High density polyethylene is used in making containers, milk and detergent bottles, bags and industrial wrapping. Low density polyethylene is used for pallet and agricultural film, bags, coatings and containers.

Polypropylenes:

Polypropylene is often termed a breathable film. This film does not provide a good gas barrier, but is used mainly for moisture barrier properties and for temperature resistance in retort or pasteurized packaging. The material has good clarity, high gloss and excellent crack resistance. Packaging material made of polypropylene are used for bottles, jars, crisp packets, biscuit wrappers and boil-in-bag films among many other applications.

Polyethylene terephthalate (PET)/ Polyester (PS)

PET is a very strong transparent glossy film, which has good moisture and gas barrier properties. It is commonly used for carbonated drinks and boil-in-bags. Polyester is a transparent exceptionally strong oriented film. It is mainly used for packaging processed meats, cheese, candy and coffee.

Uncoated polyvinyl chloride (PVC) and polyvinylidene chloride (PVDC)

PVC and PVDC are closely related plastics that are a part of the group of polymers more commonly known as “vinyl”. Its uses include “film” wrap for meats and water and cooking oil bottles. As a packaging material, PVC is most commonly formed into very thin plastic “film” (such as that used to wrap meat) and as thicker plastic “sheet,” which is molded into some type of rigid container. PVDC films are fat resistant and do not melt in contact with hot fats, making it suitable for 'freezer-to-oven' foods. It is also used as a coating for films and bottles to improve the barrier properties.

Nylon (PA) polyamides and polyethylene modifications

Nylon is a strong transparent film made of two principle polymers namely type 6 and 66 and has a combination of properties which make it suitable for a variety of industrial applications. It can be printed, laminated or extrusion coated. Nylon alone is a poor moisture barrier therefore must be coated with surlyn.

Surlyn films

Surlyn (SU) is a versatile film which is sometimes covered over polyethylene due to some unique properties such as excellent moisture barrier, high melt strength, good clarity, low temperature sealability and toughness. It is commonly used for packaging processed and fresh meats.

Laminated films

Laminated films are commonly made by the lamination of two or more films. Lamination of two or more films improves the barrier properties and/ or mechanical strength of a package. For example- laminates of nylon-LDPE, nylon-PVDC-LDPE are commonly used for non-respiring products. In such a combination, the nylon provides the strength to the pack, whereas PVDC provides the correct gas and moisture barrier properties and LDPE gives heat reliability. For products like bakery items, snack foods, confectionary, etc., the plastic based laminate in three or four layer are commonly used in order to meet the requirement of barrier properties against moisture, oxygen and light.

Co-extruded films

Coextrusion is the simultaneous extrusion of two or more layers of different polymers to form a single film. There are three main groups of polymers which are used in co-extruded films- olefins (low density and high density polyethylene and polypropylene), styrenes (polystyrene and acrylonitritebutadiene-styrene) and polyvinyl chloride polymers. These types of films have got extensive application for the packaging of fresh milk and edible oil.

Plastic woven sack

Available in laminated or non-laminated forms.

Metal

Metal is used to form rigid metal containers as well as foils to be used as rigid and flexible packaging material, respectively.

Rigid metal containers

Rigid forms of metal containers include metal cans which could be made either from aluminum, tin plate or tin free steel. But the tin plate containers and aluminum containers have got extensive application in packaging. The former being the most popular form of metal containers used in food packaging.

Tin containers were traditionally used for heat-sterilized products and are made of the plate, with a base sheet of low carbon steel with coating of tin-applied by hot dipping or electrolytic processes. Corrosion resistance, good lacquering adhesion and sole durability are the advantages of tin plate.

There are two types of tin plate containers namely open top container and general line container.

Open top containers are also called as open top sanitary (OTS) cans and are essentially round in shape. A standard open top can is supplied by can making company with bottom seamed to the body and the top ends are supplied as loose. The processed food manufacturer fills the content into the tin can and then seam with the top lid by using a machine called seamer and then the filled tin cans are subjected to heat process. This can is also called as 3-piece can. Open top sanitary cans are widely used for processed food and beverages. With the advent of easy open end, cans are now fitted with “ring pull tab” for ease of opening a can. Recently “Drawn and Wall Ironing” can (DWI can) has been developed, which is also called two piece can as the cylindrical body and bottom become single piece and lid is separate. E.g. pressurised beer and beverage cans.

General line containers are containers range of tailor made sizes and may be round as well as un-round (known as irregular) and are filled with various kinds of fitments made from tinplate, aluminum and plastics. These containers do not have much application for processed foods, rather bakery products, hydrogenated oils and confectionery items are packed in them.

However, due to shortage of metallic tin and its import costs, expensiveness, tin free steel (TFS) and aluminum containers have been developed. These are used for processed fruit and vegetable products, meat and fish and dairy products. New types include:

- High tin fillet (HTF): Developed in USA for canning type foods like green asparagus, tomato products, dried prunes, green beans, carrots etc.
- Low tin coated steel (LTS): Nominal coating of tin is used. Used for canning beer, carbonated beverages, vegetable and meat products.
- Tin free steel cans (TFS): Developed by replacing tin with chromium metal, therefore also called as Chromium steel can. Used for vegetable and meat products, milk powder, vanaspati, edible oils, which are low acid products.
- Aluminum cans: Developed as an alternative to the plating. Used for packaging carbonated beverages, beer, vegetable and meat products.

Metal containers have a number of advantages over other types of containers which are as under:

- Provide total protection of the contents
- Convenient for ambient storage and presentation

- Tamperproof.

However, the high cost of metal and high manufacturing costs make them expensive. They are heavier than other materials, except glass, and therefore have higher transport costs.

Metal foils:

Important food packaging foils consist of pure aluminum. It has the best barrier performance against moisture, gases, light, aroma, etc. compared to any of the material; therefore it has been established as the best flexible packaging material. No other flexible material can match the characteristics of aluminum because foil retains all metallic properties of aluminum. The important properties of aluminum foil are impermeability, non-toxic, stable, barrier against light and heat, tasteless and odourless.

Because of its impermeable nature it is extensively used for lamination. On its own, aluminum foil is not strong, hence needs to be laminated to a stronger material to reinforce it and make it efficient as a barrier to water-vapour and oxygen. Common reinforcement is paper. Others include regenerated cellulose, polyester, polyethylene, polypropylene.

The important applications of aluminum foils include bag , decorative label, confectionery, biscuit wrappers, milk products, multilayer laminates, stand up pouches, tea chest lining etc.

Glass:

Glass is an important package media, which has been used since many centuries. This packaging material is used for almost all types of products like liquid, powder, paste, granules, etc. Packaging properties of glass are moldability, inertness, transparency and strength etc. A variety of closures made of metal, plastic, cork or rubber, depending up on the requirement, can be chosen with glass containers. Recent development is the use of very thin glass encased in a plastic exterior providing inertness of interior surface with resistance to abrasion by the exterior surface. The advantages and disadvantages of glass packaging are presented in following text.

Advantages of Packaging

- ✓ Impervious to moisture, gases, odours and micro-organisms
- ✓ Inert and do not react with or migrate into food products
- ✓ Suitable for heat processing when hermetically sealed
- ✓ Re-useable and recyclable
- ✓ Resealable
- ✓ Transparent to display the contents
- ✓ High and low temperature resistance
- ✓ Rigid to allow stacking without container damage
- ✓ Does not taint, pollute or affect the quality of product packed in it
- ✓ May be coloured for protection from sunlight

Disadvantages of Packaging

- Higher weight incurs higher transport costs than other types of packaging
- Lower resistance than other materials to fractures, scratches and thermal shock
- More variable dimensions than metal or plastic containers
- Potentially serious hazards from glass splinters or fragments in foods

Corrugated fiber board boxes

These boxes are made from die-cut corrugated fibre board where the Kraft papers are passed through corrugating machine to get the fluting media (corrugation) and finally stuck into a plain layer of Kraft paper (linerboard) by means of adhesives or gum to form 2 layer or 2 ply corrugation roll.

Packaging laws and Regulations

The Indian Government has enacted laws to take care of quality standards of packaged foods. Standards have also been fixed for the particular kind of packaging required to be undertaken, depending on the product to be packed. The regulations on quality standards of packaging that govern food products in our country are given as under:

Standard Weights and Measures Act (SWMA) 1976 and the Standards of Weight and Measures (Packaged Commodities) Rule, 1977

It is mandatory and applicable to all commodities including foods. The emphasis is on quantity and value declaration on the label to facilitate value comparisons and protect consumer interests. The standard specifies quantities to be packed, expressions to be avoided and size of type depending on the size of the panel in a package.

The SWMA requires certain declaration to be made on every retail package, which includes common/ generic name of the product, net quantity, retail sale price, unit sale price, month and year of manufacturing or pre-packing, and name and address of the manufacturer or the packer. As far as possible, all declarations required to be made under SWMA should appear on the principal display panel (PDP) of the package.

Prevention of Food Adulteration Act, 1954 and the Prevention of Food Adulteration Rules, 1955

This is basically intended to protect health and safety of consumer and is mandatory for internal trade. The labeling rules are very elaborate and applicable to all packaged foods. The declarations include product name, net quantity, batch number, month and year of manufacture and additives incorporated and ingredients.

Fruit Products Order, 1955

This is concerned mainly with the regulation of quality and hygiene of fruit and vegetable products including beverages, syrups etc and is mandatory for export and internal trade. It also specifies the type of packages that can be used for various fruit and vegetable products. All labels should be approved by the authority and should carry the license number allotted. The batch/code number along with the date of manufacturing should also be declared.

Meat Food Products Order, 1973

This order is mandatory and regulates the licensing and labeling of meat products. It also specifies the type of packages that can be used for various meat products. All labels have to be approved by the licensing authority and number should be declared on the label.

Agriculture Marketing (AGMARK) Rules, 1937

Agricultural products such as nuts, ghee, honey, pulses, spices and condiments, vegetable oils etc. are covered under AGMARK for their quality parameters. The Agmark rules also specify the type of packages that can be used and labeling declarations that have to be given. It is voluntary for internal trade and compulsory for export of modified products.

Bureau of Indian Standards (BIS) Act, 1986 and BIS rules, 1987

The BIS has formulated specifications for packaging materials, packages and components. Also, it specifies the types of packaging materials that can be used for various types of food products. These specifications are voluntary for most of the foods, but are compulsory for certain items like food colours and packaged drinking water.

Food Safety and Standards Act, 2006 and Food Safety and Standards (Packaging and Labelling) Regulations, 2011

Under Food Safety and Standards Act, 2006, the regulations on packaging and labelling has come into force on/ after 5.8.2011 as Food Safety and Standards (Packaging and Labelling) Regulations, 2011, that overrides all existing rules and regulations related to food packaging and labelling.

UNIT 9

LABELLING AND COSTING OF THE PRODUCT

Labelling of the package

Labeling of package is done to inform the customer about the product, which is present in the package.

Food labeling can be defined as the primary means of communication between the producer and the seller of food on one hand and the purchaser and consumer on the other.

Label is a piece of paper or any other material (such as tag, brand, mark, pictorial or other descriptive method) on which the legend and design concerning the product is printed, stenciled, marked, embossed or impressed on. Label is affixed to a container/article containing the product.

Mandatory labeling requirements of prepackaged foods indicate that every package of food shall carry the following information on the label:

- Name of the food
- List of ingredients
- Declaration of food additives
- Name and address of manufacturing units/ importer
- Country of origin
- Net contents and drained weight
- Lot/Code/Batch identification
- Date of manufacture or packing
- Date marking i.e. Expiry date and Best Before Date
- Instructions for use

The Gazette of India stipulates that all food products packed should have a label indicating whether it is totally vegetarian or not. A green dot contained in a green square indicates vegetarian origin, whereas, a brown dot in a brown square denotes that the product or ingredients are non-vegetarian.

Apart from these, the Gazette of India stipulates certain additional mandatory requirements on packaged food items. These include quantitative labeling of ingredients and international irradiated foods symbol in close proximity to the name or brand of the food.

Nutrition labeling and nutrition claims:

Nutrition labeling is a description of the nutrient content of a food and is intended to guide the consumer in food selection. It consists of two components namely nutrient declaration, which means a standardized statement or listing of the nutrient content of a food and supplementary nutrition information like serving size, claims etc.

The nutrition label indicates nutritional facts to help find information fast and make general comparison without making a lot of calculations between different food products. The serving size is fixed so that the size of one serving is same for different brands of the same food, which makes comparison easier between different products. The dietary values label contains information regarding overall diet.

Nutrition claims, on the other hand, means any representation which states, suggests or implies that a food has a particular nutritional properties including but not limited to the energy value and to the content of protein, fat and carbohydrates, as well as, the content of vitamins and minerals. The information on ingredients; nutrients as a mandatory part of nutrition labeling, and quantitative or qualitative declaration of certain nutrients or ingredients on the label if required by national legislation are not included under nutrition claims.

Bar coding of food products:

Coding denotes assignment of numerical, alphabetical or symbolic identification mark to containers, packaging material or articles to provide information concerning the qualities of the contents or containers or date, plant or line in which it was manufactured. A common form of coding the packaged food is through bar coding. It is done in the form a Universal Product Code (UPC) or the bar code.

A bar code is a series of bars and spaces arranged according to the encoding rules of a particular specification in order to represent data. Its purpose is to represent information in a form that is machine-readable. The bar codes are printed as labels on packages on consumer packs for laser reading at retail checkouts. This makes the process much easier and faster and avoids the need for individual price labeling of packs and allows itemized bills to be produced for customers.

Bar coding technology is used extensively in the supply chain of goods ready for shipment and as a means of inventory control. For example, corrugated board shipping containers are bar coded to inform the carrier about the destination. A manufacturer’s code is printed on to the containers to identify the factory, the production line and the shift during which the product was made.

Costing/ Pricing of products:

Costing is a process through which we calculate the total cost required in manufacturing and selling a product or service.

A number of inputs are required when any food product is produced. All these inputs involve some kind of expenditure. Therefore, “cost” refers to a measure, which estimates the total value of these inputs in terms of money.

Types of Costs:

All costs incurred in running any entrepreneurial activity can be classified into two types:

1. Fixed costs
2. Variable costs

Fixed costs

They are the overhead costs which are fixed for a certain amount of production whether there is full capacity utilization or part of it. It does not vary with scale of production. Cost of machinery, rent, and interest on loans are expenditures that are constant irrespective of the scale of production and hence they are called fixed costs.

Variable costs

They are directly related with production and vary as the scale of production increases and decreases. The cost per unit decreases as more and more number of units are produced. The cost of raw materials, transportation and labour costs etc. vary as the production quantities vary, hence they are called variable costs.

When selling a product, make sure you make enough profit to cover both fixed and variable costs.

Total cost of the product= Fixed cost + Variable cost

Break-even point

It is the process of estimating "point of no profit and no loss" commonly known as break-even point. The break even point tells us about how many products one must sell to cover his costs

$$\text{Break-even Point} = \frac{\text{Fixed Cost}}{\text{Selling Price} - \text{Unit Variable Cost}}$$

Pricing

Pricing is the process through which a producer determines the selling price of the product. Pricing is done on the basis of cost of production, price of the same products or similar substitutes in the market and extent of profit that the producer wants to make by selling the products. Both costing and pricing are used to decide the minimum that can be charged in order to optimize profit without driving customers to competitors. The difference between the selling price and cost price is called the margin

Pricing decisions are extremely important since they directly influence the profitability of an enterprise. Some of the factors that should be taken into account while determining the price of a product are:

- The selling price of the same product in the market
- The total cost of the product
- Buying behaviour of the customers
- The amount of profit the producer want to earn
- Kind of product whether seasonal/ annual

- Discounts/ favours the producer like to offer

Pricing Methods - Methods commonly used for fixing price of a product are:

Market rate method

This is adopted when all producers are charging more or less the same price. The price is guided by the prevailing market rate. The advantage of this method especially for new microenterprises, is that they get some immunity from the vagaries of price fluctuation.

Cost plus pricing

This is done considering the total cost of the product and the extent of profit the producer wants to earn. Total cost is the sum of variable cost and fixed costs attributable to one unit of output. A margin of profit is then added to determine the price.

Discount Pricing

Most producers adjust their price lists and give discounts and allowances for early payment, volume, purchase and off season buying. Some of the methods used for pricing discount are:

- Cash discount: A cash discount is a price reduction to buyers who pay their bills promptly.
- Quantity Discounts: A quantity discount is a price reduction to those buyers who buy large volumes.
- Seasonal discounts: A seasonal discount is a price reduction to buyers who buy products during the off seasons.

UNIT 10

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