POST HARVEST TECHNOLOGY

3RD SEM AGRI. ENGG.

Unit 1

CLEANING, GRADING & SORTING OF AGRO COMMODITES 1. INTRODUCTION Cleaning and sorting of agro commodities is in practice since ancient time. Initially, this process was carrying out at household level is now scaled up to industrial level looking to production and demand of all these commodities. It is necessary to clean, grade and sort all raw cereals, pulses, legumes, oil seeds and whole spices before any type of consumption or use in other products. Cereals, pulses, legumes, oilseeds and whole spices are needed specific postharvest operations, start right from farm after harvesting, and divided into three stages: 1) Farm Level Operations; 2) Primary Processing and 3) Secondary Processing. The farm level operations include are: threshing, winnowing, drying and storage. The primary processing of whole agro-commodities include: cleaning, grading, sorting and packing; whereas, secondary processing includes value addition like grinding (flour or powder making); blending, flaking, baking, roasting, puffing, etc. It is necessary to use cleaned and sorted grains, pulses, legumes and whole spices for further value addition.

(I) MACHINES FOR CLEANING, SORTING OR GRADING SEED, GRAIN OR DRIED LEGUMINOUS VEGETABLES This heading covers machines, whether of horticultural, agricultural or industrial types, of a kind used for cleaning, sorting or grading cereal grains, dried leguminous vegetables, seeds, etc., by winnowing, blowing, sieving, etc. Such machines include : (1) Fanning mills consisting of a feeding hopper, a blower and sieves (usually vibrating). (2) Grading winnowers, rotating winnowers and seed or grain selectors, more complex machines which clean by means of air currents, and grade the seed or grain according to weight, size or shape. Some seed selectors, etc., incorporate auxiliary devices for coating the seeds with insecticide powders, etc. (3) Sieving belts, often used for cleaning beet seed. They consist of a series of rolls operating an endless inclined belt running under a feeding hopper. The seeds roll freely to the bottom of the belt but the light vegetable waste adheres to the plushy surface of the belt fabric. (4) Special machines for selecting and grading seed for planting. This heading also covers machinery used in the milling industry for cleaning, sorting or grading grain prior to milling. Some of these machines are based on the same principles as the winnowing, screening and grading machines described above, but are designed for larger output and are specialised for the milling industry, e.g. : (1) Cyclone separators for cleaning the grain. (2) Machines for cleaning and grading by the action of revolving pocketed or perforated drums. (3) Aspirator separators with oscillating sieves.

(4) Separators and graders of the magnetic or electro-magnetic types. (5) Washing, stone-removing and " whizzing " machines, with or without subsidiary drying columns. (6) Grain brushing machines. (7) Grain dampening machines, whether or not incorporating heating or weighing apparatus. The heading also includes combined machines which clean, sort and grade simultaneously, including machines incorporating devices for electro-magnetic separation.

.Scope and importance of food processing Technology 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.

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 1.1.

Table 1.1 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

UNIT-II Engineering Properties of Agriculture Materials :-

These are the properties which are useful & necessary in the design & operation of various equipment employed in the field of agriculture processing & also for design & development of other farm machine. In the operations while handling of grains & other commodities the properties which play an important role are physical, mechanical, frictional, aero & hydrodynamic, electrical & optical properties of the bio materials. Basic information on these properties are of great importance and help help for the engineers, food scientists & processors towards efficient process & equipment development.

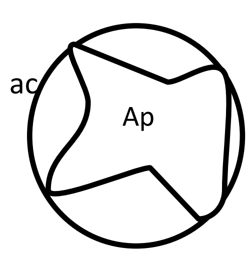
1. Physical properties :- The physical properties such as size, shape, volume, surface area, density, porosity, colour & appearance are important in designing a particular equipment or determing the behaviour of the product for its handling.

Some of the important physical properties are described below :-

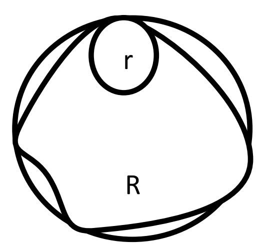
Shape & size :- The following parameters may be measured for describing the shape & size of the granular agricultural materials.

Roundness :- It is the measure of the sharpness of solid materials method used for determining the roundness of irregular particular given below :-

Roundness / Fig (a) = largest projected area of the partical when it is in natural rest position, AP / Area of smallest circumscribing circle, Ac



(a)



(b)

Round ratio/fig (b) = Radius of curvature, r, of the sharpest corner/mean radius of the particle, R

Sphericity :- It may be defined as the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest dia of the particle

Sphericity = De/Dc

Where :- De = The dia of a sphere having same volume as that of the particle

Dc = The dia of smallest circumscribing sphere

Density & Specfic Gravity :- The density of any material may be expressed as :

Density = Wt. of the material, kg/volume of the material,m^3

The density & sp. Gravity volume of grain & other commodities are used in design of storage bin & soil, separation of desirable materials from impurities, cleaning & grading evaluation of grain maturity, texture and softness of fruits, quality evaluation of the products etc.

Specific gravity = Wt. m air x specific gravity of water / wt. of displaced water

2. **Aero & Hydrodynamic Properties :-** The aero & hydrodynamic properties such as terminal velocity of agricultural products are import & required for designing of air & water converting systems & separation equipment. e.g. in pneumatic conveying & separation processes the material is lifted only when the air velocity is greater than its terminal velocity.

Drag Coefficient & terminal velocity :- The terminal velocity of a particle may be defined as equal to the air velocity at which a particle remains in suspended state in a vertical pipe.

Grains	Terminal velocity m/sec.
Wheat	9 - 11.5
Barley	8.5 - 10.5
Soybeans	44.3
Corn	34.9

Frictional Properties :- The frictional properties such as coefficient of friction & angle of repose important in designing of storage bins, hopper, chutes, pneumatic conveying system, screw conveyers, forage harvester & threshers etc. Rolling resistance of agri materials is useful in designing of handling equipment e.g. conveying of fruits and vegetables by gravity flow. Hence the knowledge of frictional properties of agri material is necessary there for some of the important frictional properties of agri products are described here as below :-

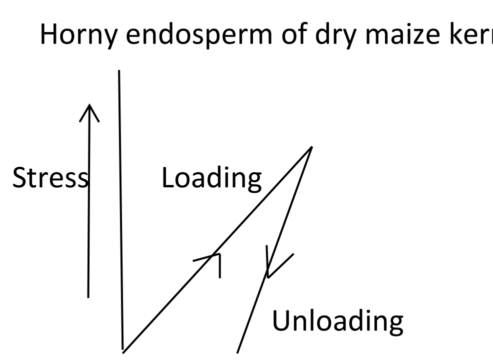
1. **Static Friction :-** The friction may be defined as the frictional forces acting between surfaces of contact at rest with respect to each other.
2. **Kinetic Friction :-** It may be defined as the friction forces existing between the surfaces in relative motion.

   It 'F' is the force of friction & W is the force normal to the surface of contact then the coefficient of friction **ƒ** is given by the relation ship.

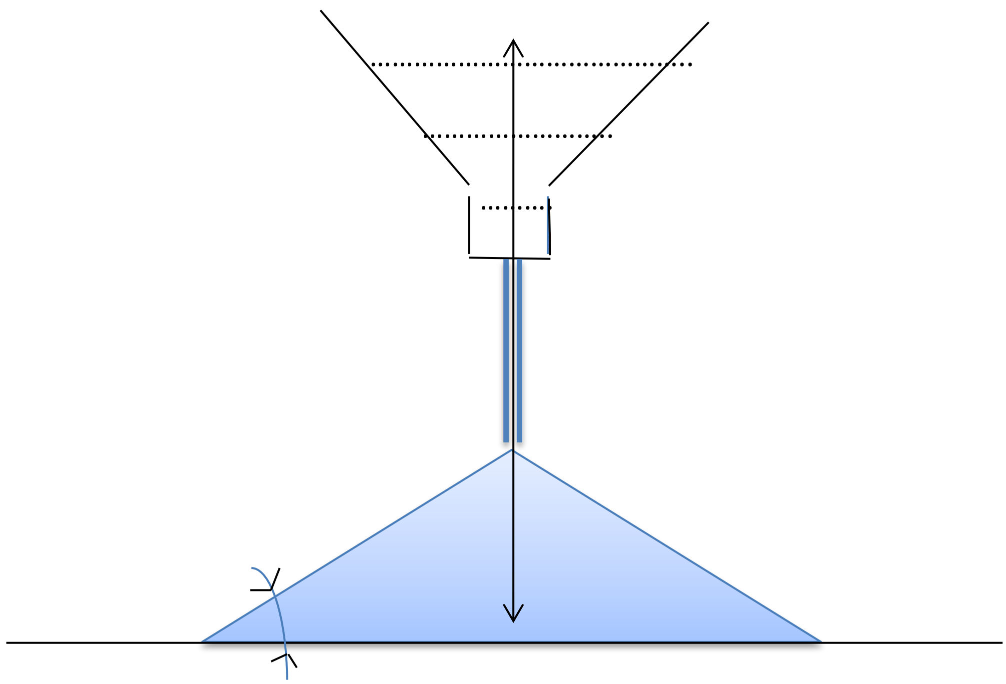
   $$ƒ = F/W$$

   The coefficient of friction may also be defined as the tangent of angle of the inclived surface upon which the friction force tangential to the surface & component of the weight normal to the surfaces are acting.
3. **Rolling Resistance :-** The rolling resistance is directly proportional to the wt. of the rolling object & to the coefficient of rolling resistance which is dependent on the rigidity of supporting surface & indirectly proportional to the effective radius of the rolling object.
4. **Elasticity :-** The hooke's law states that stress is directly proportional to strain within elastic limit.

   But is any real material, perfect elastiaty may not be obtained. Also in alastiaty, the complete recovery of strain takes place upon removal of stress. The compression fest conducted on some of the products like fruits & vegetables, cereal grain,etc shows that elasticity does not exist in there biological material eventor very small stains. A typical example of first cycle of loading & unloading for the horny endosperm of dry maize kernel has been shown in fig:



5. **Angle of Repose :-** The angle of redoes is the angle between the base & the slope of the cone formed an a free vertical fall of granular material ta a horizontal plane. The size, shape, moisture content & the orientation of grains affect the angle of repose.
   The angle of repose is an indicator of the product's ability to flow. Each product has its own natural angle of repose. The cohesive materials has larger angle of repose, whereas the lower angle of repose represents easier flow ability of the product.
   [Wheat = 23-28*, Paddy = 30-45* angle of repose]



<u>Angle of Repose</u>

Mechanical Properties :- Mechanical properties may be defined as those which affect the behaviour of the agril material under the applied force. The mechanical properties such as hardness, compressive strength, impact & shear resistance affects the various operations of agricultural processing.

The mechanical damage to grain & seed in threshing & handling operations causes reduction in germination power & viability of seeds, increases the chances of insect & pest infestation & also affect the quality of final product.

The hardness of the grain effect the milling characterstices & it is also useful to live stock feeders & plant breeders.

The impact & shear resistance are important for size reduction of food grains. These information are useful in determination of the appropriate methods of crushing, breaking or grinding the grains. These properties also play important roles towards seed resistance to cracking under harvesting & threshing conditions.

Thermal Properties :- Thermal properties like sp. Heat, thermal conductivity, thermal diffusivity, enthalpy, surface heat transfer, etc. are important to the development of any thermal processing system. Thermal processing may includes heating, cooling, freezing, drying, etc.

The heat treatment to cereals & some of the pulses is given for stimulating germination. The heat treatment given to cereals like wheat, maize, sorghum & few millets for thermal killing of insect-pest in storage has been proved to be a promising technology. In all the calculations of heat treatment the heat balance for heating is worked out with the knowledge of sp. Heat & thermal conductivity. To design a dryer, the calculations of heat requirement is the most important step.

Some of the important thermal properties are as given below:

(i) **Specific Heat :-** The specific heat may be defined as the amount of heat in kilocalories that must be added to or removed from 1kg of a substance to change its temp. by 1'c.

The sp. Heat of wet agricultural material is sum of the sp. Heats of bone dry material & its moisture content. If C_d & C_w are the sp. Heats of bone dry material & water respectively, and m is the moisture content of the material in present wet basis, then the sp. Heat can be expressed as:

$$C=[m/100]C_w + [100-m/100]C_d \text{ k.cal/kg 'c}$$

(ii) **Thermal Conductivity :-** It may be defined as the rate of heat flow through unit thickness of material per unit area normal to the direction of heat flow and per unit time for unit temp. difference. It is the measure of ability of the material to conduct heat.

The thermal conductivity can be expressed by the following equations:

$Q = KA \Delta T$

Where : Q – Amount of heat flow, kcal.., A=area, m^2

Δ T- temp. difference in the direction of heat flow, 'c

K- thermal conductivity, kcal/m.hr 'c

(iii) **Thermal Diffusivity :-** It may be calculated by dividing the thermal conductivity with the product of sp. Heat and mass density.

i.e. $u = K / ƒC_p$

Where : K – thermal conductivity

U – thermal diffusivity

Ƒ – mass density

C_p- specific heat

Thermal diffusivity is important in determination of heat transfer rates in solid food materials of any shape.

UNIT-III DRYING – GRAIN DRYING, TYPES OF DRYING, TYPES OF DRYERS, IMPORTANCE OF DRYING

- Permits long time storage of grain without deterioration
- Permits continuous supply of product thro' out the year
- Permits early harvest which reduces field damage and shattering loss
- Permits the farmers to have better quality product
- Makes products available during off season

Drying theory

- Convection process in which moisture from a product is removed
- The water content of agricultural product is given in terms of moisture content
- They gain or loose moisture as per the atmospheric conditions
- Moisture migration into or from a product is dependent on the difference of vapour pressure between atmosphere and product
- If the vapour pressure of grain is greater than atmospheric vapour pressure, transfer of moisture from grain to atmosphere takes place
- If the atmospheric vapour pressure is greater than grain vapour pressure, grain absorbs moisture from atmosphere

Drying rate periods

Divided into 3 periods

- Constant rate period
- First Falling rate period
- Second falling rate period

Constant rate period

- Moisture migration rate from inside of product to its surface is equal to the rate of evaporation of water from surface
- This period continues till critical moisture content is reached
- Critical moisture content: Moisture content of a product where constant rate drying ceases and falling rate starts
- This period is very short for agricultural products
- Drying of sand and washed seeds takes place in constant rate period

Falling rate period

- Most of the agricultural products are dried in falling rate drying period
- Movement and diffusion of moisture in interior of grains controls the entire drying process

Controlled by

- Migration of moisture from interior of grains to upper surface due to water vapour diffusion
- Removal of moisture from the surface
- Divided into two periods
- First falling rate period
- Second falling rate period

First falling rate

- Unsaturated surface drying
- Drying rate decreases because of the decrease in wet surface area
- Fraction of wet surface decreases to zero, where first falling rate ends

Second falling rate

- Sub surface evaporation takes place & it continues until the equilibrium moisture content is reached

Mechanism of drying process

- Movement of moisture takes place due to
- Capillary flow – Liquid movement due to surface forces
- Liquid diffusion – Liquid movement due to difference in moisture concentration
- Surface diffusion - Liquid movement due to moisture diffusion of the pore spaces
- Vapour diffusion – vapour movement due to moisture concentration difference
- Thermal diffusion - vapour movement due to temperature difference
- Hydro dynamic flow – water and vapour movement due to total pressure difference

Thin layer drying

- Process in which all grains are fully exposed to the drying air under constant drying conditions i.e. at constant air temp. & humidity.
- Up to 20 cm thickness of grain bed is taken as thin layer
- All commercial dryers are designed based on thin layer drying principles
- Represented by Newton's law by replacing moisture content in place of temperature M-Me/Mo-Me = e -Kθ

M – Moisture content at any time θ, % db

Me- EMC, %db

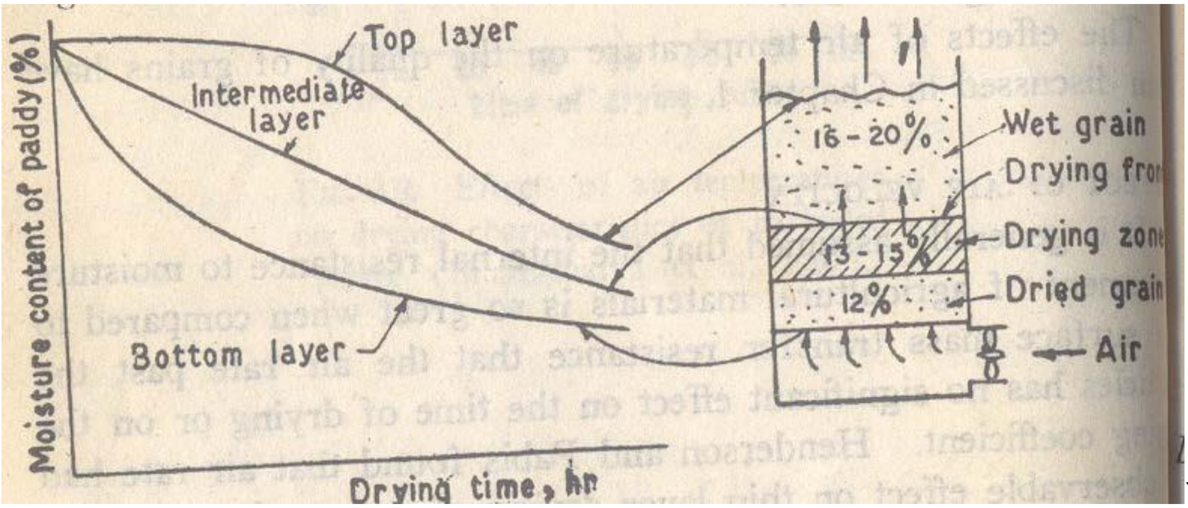
Mo – Initial moisture content, %db

K – drying constant

θ - time, hour

Deep bed drying

- All grains are not fully exposed to the same condition of drying air
- Condition of drying air changes with time and depth of grain bed
- Rate of airflow per unit mass of grain is small
- Drying of grain in deep bin can be taken as sum of several thin layers
- Humidity & temperature of air entering & leaving each layer vary with time
- Volume of drying zone varies with temp & humidity of entering air, moisture content of grain & velocity of air



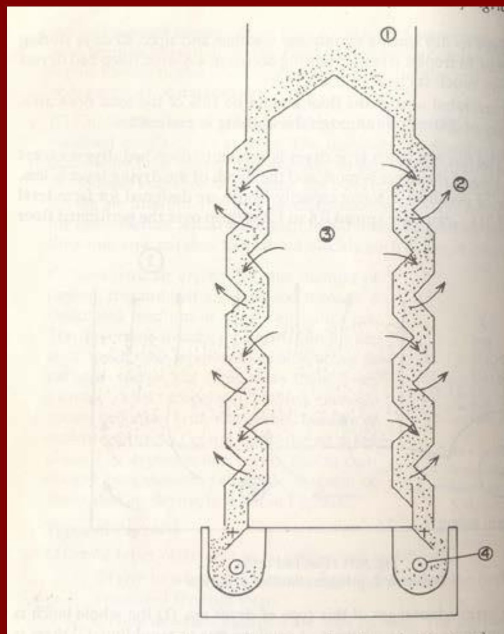
Deep bed drying characteristics at different depths

Continuous flow dryer

- Columnar type dryer in which wet grains flow from top to the bottom of the dryer
- Two types
- Mixing
- Non-mixing

Mixing

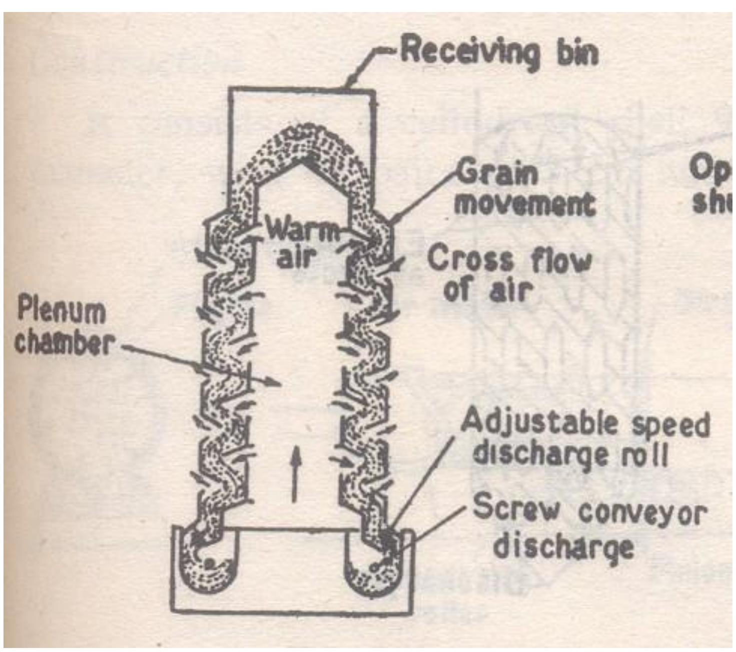
- Grains are diverted in the dryer by providing baffles
- Use low air flow rates of 50-95 m3/min/tonne
- Zig-zag columns enclosed by screens are used to achieve mixing
- High drying air temperature of 65°C is used



1. Feed hopper
2. Exit air
3. Plenum chamber
4. Dry material outlet

Baffle dryer

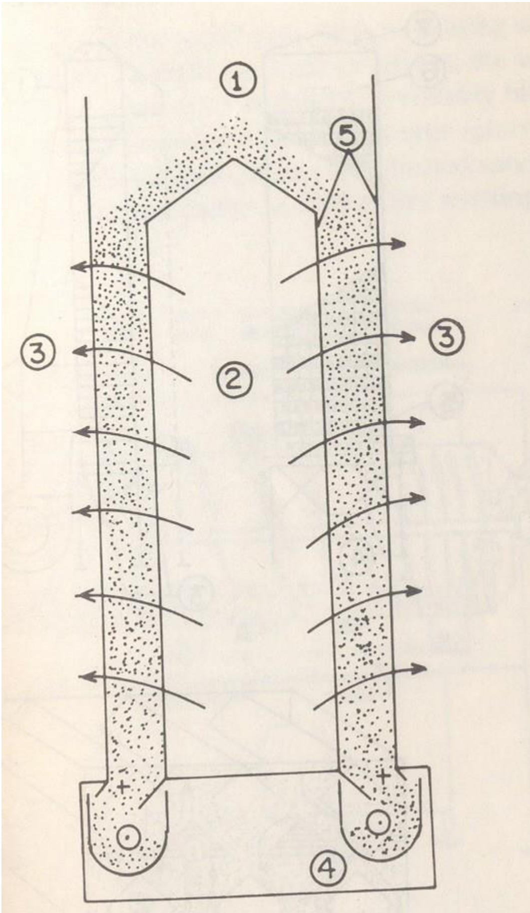
- Continuous flow mixing type dryer
- Consists of receiving bin, drying chamber fitted with baffles, plenum fitted with hot air inlet
- Baffles are fitted to divert the flow & also for mixing
- Grain fed at the top & move downward in a zig-zag path where it encounters a cross flow of hot air
- Bucket elevator is used to recirculate the grain till the grain is dried to desired moisture level
- Uniformly dried product is obtained



Mixing type baffle dryer

Non-mixing

- Grains flow in a straight path
- Baffles are not provided and drying takes place between two parallel screens
- High airflow rates can be used
- Drying air temp. of 54°C is used



1. Feed hopper
2. Plenum chamber
3. Exit air
4. Dry grain outlet
5. Screened grain column **Continuous flow dryer (Non-mixing)**

Recirculatory Batch dryer

- Continuous flow non mixing type
- Consists of 2 concentric circular cylinders, set 15-20 cm apart

Bucket elevator is used to feed & recirculated the grain

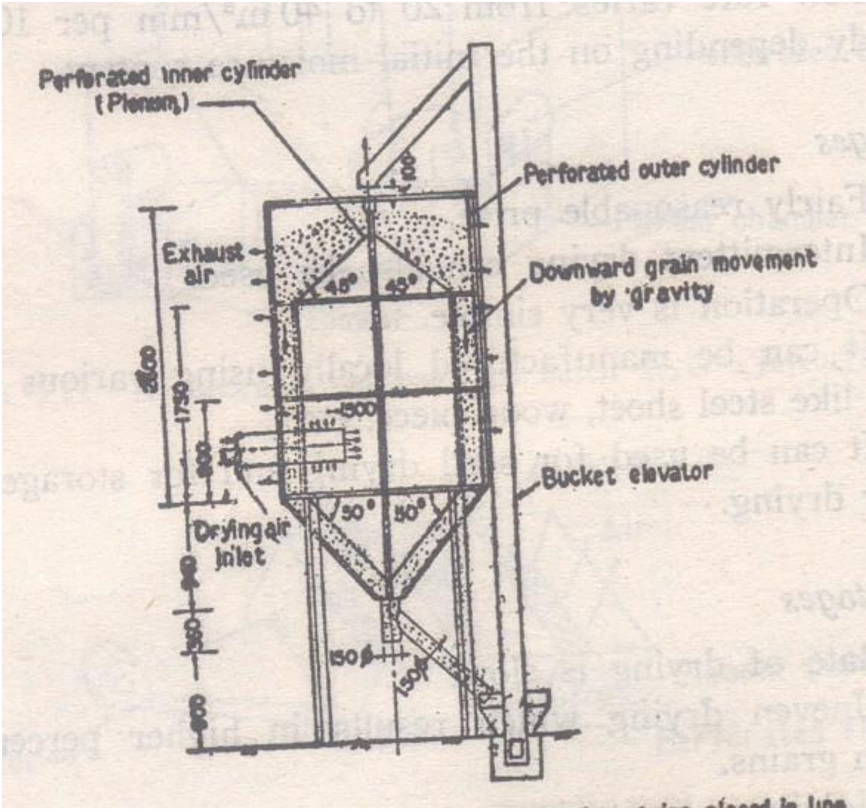
Centrifugal blower blows the hot air into the inner cylinder, acts as a plenum

Grain is fed at the top of the inside cylinder; comes in contact with a cross flow of hot air

The exhaust air comes out through perforations of the outer cylinder

Grain is recirculated till it is dried to desired moisture content

Drying is not uniform as compared to mixing type

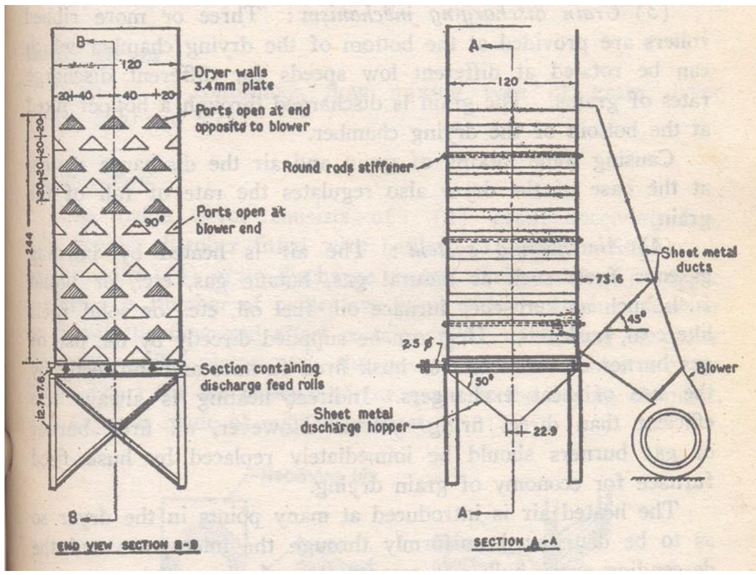


Recirculating batch dryer

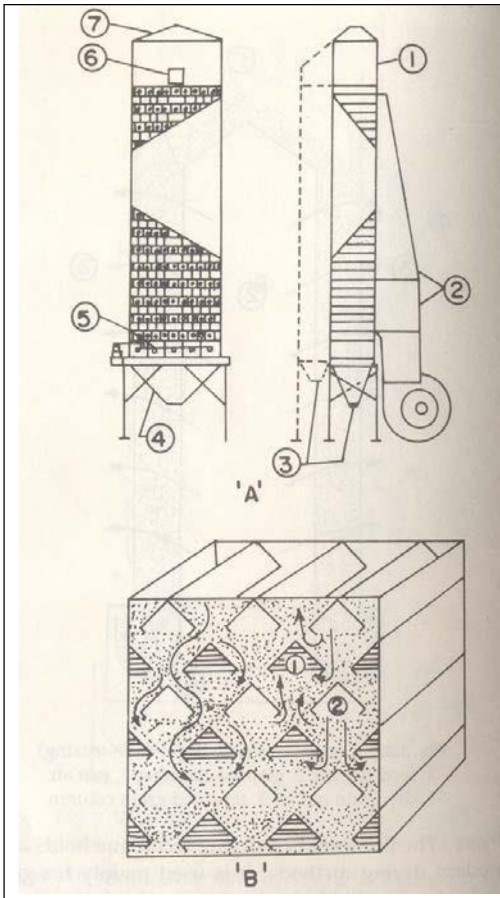
LSU dryer

- Developed at Louisiana state university (LSU)
- Continuous mixing type dryer
- Developed specifically for rice to ensure gentle treatment, good mixing & good air to grain contact
- Consists of rectangular chamber, holding bin, blower with duct, grain discharging mechanism and air heating system
- Layers of inverted V shaped channels are installed in the drying chamber; heated air is introduced through these channels at many points
- Alternate layers are air inlet & outlet channels; arranged one below the other in an offset pattern
- Inlet port consists of few full size ports & two half size ports; all ports are of same size arranged in equal spacing
- Ribbed rollers are provided at the bottom of drying chamber for the discharge of grain
- Capacity varies from 2-12 tonnes

- Recommended air flow rate is 60-70 m3/min/tonne
- Air temp. are 60 &85°C for raw & parboiled paddy
- Uniformly dried product can be obtained
- Can be used for different types of grain
- High capital investment



LSU Dryer

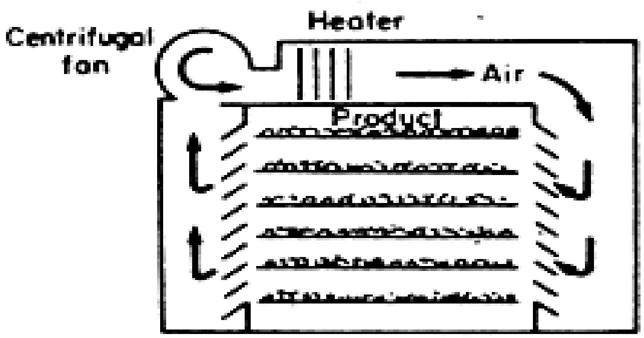


1. Garner
2. Duct
3. Dry material outlet
4. Hopper
5. Continuous flow
6. Door
7. Roof

LSU Dryer

Tray driers

- In tray dryers, the food is spread out, generally quite thinly, on trays in which the drying takes place.
- Heating may be by an air current sweeping across the trays, or heated shelves on which the trays lie, or by radiation from heated surfaces.
- Most tray dryers are heated by air, which also removes the moist vapours.

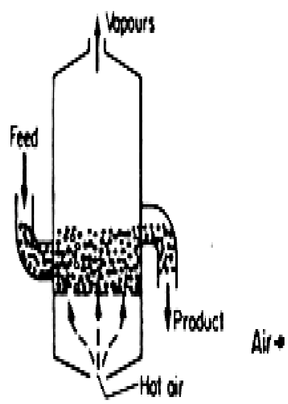


TRAY DRYER

Fluidized Bed Dryers

In a fluidized bed dryer, the food material is maintained suspended against gravity in an upward-flowing air stream.

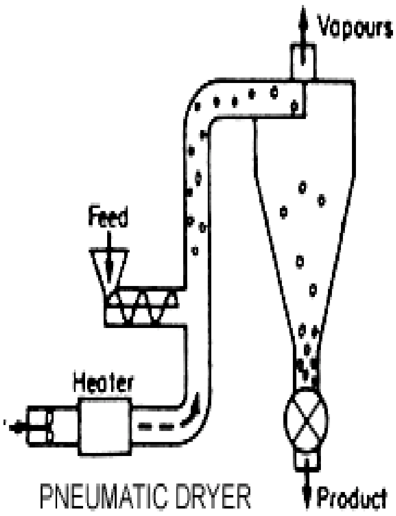
Heat is transferred from the air to the food material, mostly by convection



FLUIDISED BED DRYER

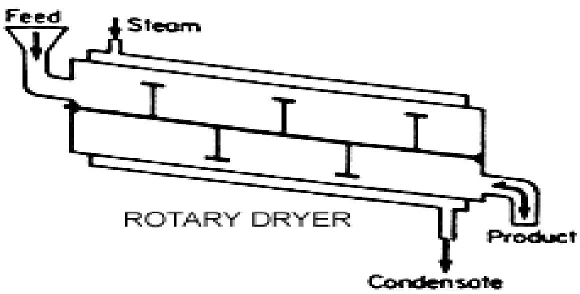
Pneumatic Dryers

- In a pneumatic dryer, the solid food particles are conveyed rapidly in an air stream, the velocity and turbulence of the stream maintaining the particles in suspension.
- Heated air accomplishes the drying and often some form of classifying device is included in the equipment.
- In the classifier, the dried material is separated, the dry material passes out as product and the moist remainder is recirculated for further drying



Rotary Dryers

- The foodstuff is contained in a horizontal inclined cylinder through which it travels, being heated either by air flow through the cylinder, or by conduction of heat from the cylinder walls.
- In some cases, the cylinder rotates and in others the cylinder is stationary and a paddle or screw rotates within the cylinder conveying the material through.



Storage

UNIT-IV Introduction:-

Storage is a transit of agricultural products from producer to processor & its products from processor to consumer. Storage of grain & control of quality occur in three locations, on the farm at collection points serving a no. of farm, & at terminal points where grain is processed or moved forward in still larger bulks.

Importance & Needs of Storage:-

Storage of food grains is inevitable both in times of deficit & surplus production. Since uncertainties of weather conditions prevailing on the surface of earth affect the total production of food grains & other food materials. Hence all the countries will have to maintain a buffer stock of food grains, fruits & vegetables, feed & fodder, sugar & oil etc. to sustain the human & animal population.

All the farmers store food grains for their own consumption also. Storage of grains & other agricultural product is necessary to provide consistent supply with the demand to provide surplus storage to carry over supplies in the years of low production & to adjust & maintain quality consistent with the intended use of product.

Principles/Requirement of Storage/Control of Losses :-

The main principal or requirements of the storage are or follows:-

(i) It should provide adequate protection from rodents, birds, insects, etc.
(ii) It should permit aeration & fumigation when required.
(iii) It should prevent losses due to moisture & temperature etc.
(iv) It should permit easy inspection.
(v) It should facilities proper cleaning & should be self-cleaning if it is silo.
(vi) It should be economical on unit storage cost basis.

Losses During Storage :-

Qualitative Losses: The qualitative loss in storage may be due to chemical change in protein, carbohydrate & fat & by the contamination. And

Quantitative Losses: The quantitative loss in storage may be on account of the activities of the birds, rodent, insects, enzyme activity of microorganisms, etc.

The main factors responsible for the losses in quality of grain are insects, rodents & dampness. Damage by insect, posts results in food grain becoming weevilled, causing losses not only in weight but also in food value, leakage of water through roof, & dampness in the structure through floors & side wells make the grain deteriorate in many ways. One of the several effects is excessive oxidation which causes a rise in temp. of the grain , including its heating & cake formation. Moisture also encourages fungus, mould & termite growth, at times rendering the entire grain stock unfit for human consumption. Besides this rats cause serious loss by eating or breaking the grains in to pieces.

Post Harvest to Increase Self Life of Fruits & Vegetables:-

The storage life of crops can be extended by various treatments applied to the post harvest. Exposing the crop to high & low temp and a variety chemicals are applied to crops after harvest to control diseases, decay or affect the crop's metabolism. Some of the treatments are given as :

1. **Low Temperature:** The freezing point of fruits & vegetable is just below the freezing point of water. Where crops are exposed to temp. below freezing point cell sap they are damaged & this is called freezing injury. Generally, over the range of ambient temp. down to the temp. at which crop will freeze, the lower the temp. the longer the storage life. Chilling injury is where crops develop temp associated physiological disorders when exposed to temp above those which could cause them to freeze.
   Post harvest temp. can also affect crop carbohydrate metabolism, spouting & pigment levels.
   (a) Precooling: To achieve the maximum storage for crop, it should be kept at the temp. just above that which will cruse chilling or freezing injury, as quickly as possible after harvest. This is know as crop precooling.

(b) **Icing:** Ice can be applied as an ice slurry which is housed on to the top of the crop from a tank and also sodium chloride to lower the melting point of the ice.

(c) Room Cooling: This method simply placing the crop in to a cold store where the crop is to be stored for a long periods.

(d) Hydro cooling: To achieve maximum effect the cooled water must constantly be passed over the crop. This can be done by submersing the crop in old water which is constantly being circulated through a heat exchanger. Chorine may be added to the water if required.

(e) Vacuum Cooling: Cooling is achieved by the latent heat of vaporization rather than conduction. The speed & effectiveness of cooling is related of the ratio between the mass of the crop & its surface area. With vacuum cooling of leaf vegetables the reduced pressure is exactly the same around the leaves in the center as it is around the leaves on the out side. This means the cooling is very even & quick throughout the crop.

(f) Thermal Disinfestation:- Exposing crops to low temp. can be used to kill insects pests post harvest especially to control infestations of insects such as increase in number & result in higher wastage. Storage of yarn tubers at 13’c was shown to prevent an increase in nematode number & thus prevent spoilage.

2. <u>High Temp</u> :- Exposure of fruits & vegetables to high temp. post harvest generally reduces their storage or marketable life high temp. treatment may have beneficial effects, for example in curing root crops, drying bulb crops & controlling disease & pests in some fruits.

(a) Dehydration (Drying) :- Dehydration is carried out to preserve fruit & vegetables by reducing their water activity below that which will support the growth of micro organism & action of enzymes. The drying is carried out to aid the preservation of vegetables in a fresh state. Traditionally, drying of onions has been carried out in the field & called windrowing. This involves pulling the bulbs from the ground when they are nature & laying them on their sides to dry for 1 or 2 weeks.

(b) Hot Water Treatment :- Crops may be immersed in hot water before storage to control diseases. A common diseases of fruit which can be successfully controlling in this way is anthracnose, caused by infections of the fungus.

(c) **Degreening :-** Oranges are often degreened after harvest by exposing them to ethylene gas, either by an initial injection of the correct level or by continuously trickling it in to the room.

3. **Chemical Treatments :-** Chemicals are applied to crops post harvest to control micro-organisms & to control post infestation, to correct nutrient imbalances in the crop which may shorten its storage life.
   (a) **Micro-organism Control :-** A large number of chemicals are applied to control fungi which causes diseases. Residue levels of chemical fungicides in the crop are related to the concentration of the chemical used, but also to the time of the crop in storage & formulation of the fungicide.
   (b) **Dusting :-** Various dusts can be applied to crop post harvest to control post harvest diseases. Wood ash is commonly used for this purpose or some time lime.
   (c) **Chemical Pads :-** Normally post harvest disease control is achieved by dipping or spraying the fruit with fungicide when it is taken to the pack house. The pads are made from several layers of soft paper previously soaked in a fungicide & them dried. Potassium aluminum sulphate may be added to the pads, which help to coagulate the latex.
   (d) **Application of Minerals :-** If certain nutrient is available in low quantities it can lead to deficiencies in the crop, which is turn can result in a loss of storage life. Post harvest application of calcium can be used for apples to reduce the development of physiological disorders during storage.
   (e) **Fruit Crating :-** Fruit are dipped or sprayed post harvest with a range of minerals to improve their appearance or delay deterioration. The effect was to extent the storage life of the fruit. The composition of the coating material was a water soluble high polymer such as a polysaccharide.

Controlled Atmosphere Storage :-

Controlled atmosphere (C.A.) extends the storage life of fresh fruit by reducing the amount of oxygen present in the storage area, while C.A. storage does or replace regular cold storage, it does work in conjunction with it.

All the fresh fruit continue to respire after harvest i.e. may taken on oxygen & give off carbon dioxide. Many fruits ripen after harvest. Under controlled atmosphere method of storage respiration & ripening may be reduced further by lowering the oxygen content of the air, which normally consists of 21% oxygen, 78% nitrogen & 1% other elements.

Two principal techniques are used to reduce the %age of O_2 in C.A storage rooms. The first allows the natural respiration of the fruits of replace oxygen with CO_2. The end & much faster method involves controlled atmosphere storage. This system removes the oxygen from the room & replaces with Co_2.

Management of Storage Structure/Stored-grain Insect Pest Management

Managing stored grains requires the use of various techniques to ensure that the quality of the grain entering the storage facility does not deteriorate over time. These measures include: the use of sanitation: storing sound, dry grain: managing temperature and aeration; and using chemical protectants, regular, sampling, and fumigation Bin facilities play an important role in determining whether gratis quality is maintained and should be inspected. Regular monitoring will help to ensure that grain quality will be maintained at the highest level possible.

1. **Bin Facilities**

   Bin facilities should be weather tight, rodent proof, steel, and on a moisture-proof concrete base. Bins should be equipped with a perforated-floor aeration system and weather-proof roof vents. All bins should be inspected on a regular basis to guard against leaks, condensation, and deterioration of any kind.

2. **Sanitation**

   Before adding grain to a storage facility, make sure it is clean and free of old grain, trash, and insects. Be sure the walls, ceiling, sills, ledges, floors, loading/unloading equipment, and the ventilation system (under perforated floors, ducts and fan system) are clean. The area outside the bin should also be free of insects, weeds, and grain products. Insects can breed and persist in these areas and infest new grain when it is placed in the bin. It is best to clean and treat storage facilities at least two weeks prior to adding new grain.

3. **Grain Moisture**

   As a general rule, grain stored for extended periods of time should contain no more than 12 percent moisture. Insects and fungi do not develop well in grain with a moisture content of 12 per cent or below.

4. **Temperature and Aeration**

   Grains harvested and stored in the hottest part of the year stand a greater chance of becoming infested, since insects reproduce rapidly at temperatures in the range of 60°-90° F. Farm-stored wheat, rye, barley, or oats are more likely to have insect problems than corn or beans, which are harvested during the cooler months of the year. Bin aeration during times of low outside temperature and humidity will aid in reducing the temperature of the grain.

5. **Empty-bin Treatment**

   Empty-bin insecticide applications are encouraged to prevent the infestation of new grain by existing insect populations. Empty-bin sprays are highly recommended when grain is stored in the summer, if there are areas difficult to clean, or if there has been a history of insect problems. After bins have been properly cleaned and inspected and prior to adding new grain, treat the facility with a labeled insecticide.

6. **Chemical Grain Protectants**

   Grain protectants may be added when the bin is being filled to guard against insect damage. Protectants may also be added to the upper surface of the grain.

   It is recommended that grain protectants be applied after high- temperature drying has been completed and the grain has been cooled.

7. **Fumigation**

   Fumigation should only be conducted by trained, experienced, registered applicators. If insects are found above the suggested thresholds, fumigation is recommended. The goal of fumigation is to maintain a toxic concentration of gas long enough to kill the target pest population.

   Fumigant selection should be based on the following factors: pest susceptibility. volatility, penetrability, corrosiveness, safety, flammability, residues, odors, application method, required equipment, and economics.

UNIT-V Post Harvest Losses of Fruits & Vegetables

Post harvest losses are losses occurring in the period between harvesting & consumption. The term "losses" includes all types of losses for the farmer, trader & consumer (e.g. weight loss, quality loss, financial loss, loss of goodwill, loss of marketing opportunities, loss of nutritional value, etc.) There are classified as :

1. **Direct Losses**

   (A) Mechanical Injuries :- Losses caused by mechanical injuries includes cuts, bruises, abrasions & punctures etc.

(B) **Physical & Environmental Losses :-** These includes the various responses of produce to excessive or insufficient heat, cold, gases or humidity.

(C) **Biological & Microbiological Losses :-** These losses refers to the consumption of or damage to produce by insects, birds, rodents, bacteria, etc.

(D) **Chemical & Physiological Losses :-** These include undesirable reaction between chemical compounds & contamination with harmful substances such as certain pesticides.

2. Indirect Losses

(A) **Consumer Demand :-** Include nice looking packaging material for local produce.

(B) **Inadequate Marketing Systems :-** The large number of people involved in marketing of produce contributes to greater losses.

(C) **Facilities :-** Limited access exists to facilities such as stores, cold rooms, drying & curing rooms.

(D) **Policy Changes :-** e.g. Agricultural diversification, Quality standards & Price policy.

(E) **Lack of Training & Awareness :-** Among people involved in marketing.

(F) **Underdeveloped Infrastructure :-** Roads, Harbour facilities.

(G) **Cost of Transport :-** The inter island freight cost is paid per unit, whether it is a box, crates or basket. As a result product losses are high & crates are to heavy & too large to be carried by one person.

(H) Unreliable supplies of packaging or high cost of packaging.

Importance of Storage of Fruits & vegetables

1. Increase the self life of the crops.
2. Prevent the decay of product during the storage.
3. The product can be used for a long period.
4. It avoid the quality losses i.e. maintain the nutritive value of the product.
5. Storage also prevent quantity losses of the product.

Need of Storage

Storage is the basic need for the storage of fruits & vegetables. During the seasons of particular crop , if the production is more than the utilization. There for the storage of that crop become necessary to avoid the wastage & to increase the self life of that crop, so that it can be used for a long period i.e. in off season also.

Packaging :- The action of putting a product in to a package or forming a package around a product which is concerned with protection, economy, convenience and promotional consideration.

The aim of packaging is to protect the product during handling, transportation and storage until the consumer finally uses it. The self life of a product is based on the protection required for the product under ideal packing and storage conditions.

Types of Packaging :- The type of packaging is determined by the nature of the product. Some of packaging types are: /Materials

1. **Second hand Containers :-** Harvesting produce into cartons, wooden boxes or metal cans which have been used for other commodities is common practice for small scale farmers.
2. **Bags and Sacks :-** Many crops are harvesting into bags, which may be made from a variety of materials such as paper, polyethylene film, sisal, woven polypropylene. This is relativily cheep & commonly used for crops such as potatoes, onions and pumpkins where some damage occurs to the fruit.
3. **Woven Baskets :-** These are traditional containers into which crops are placed after harvest. The shape of baskets, which are usually circular or at least rounded corners, gives less storage for a given than other types of containers.
4. **Wooden Field Boxes :-** Bruce boxes are made from thin pieces of wood bound together with wire. They are developed in the USA. Where fruit was put into them at harvest for transport to wholesale & retail markets. They provided little protection from mechanical damage during transport. They may be used for crops like cabbages.
5. **Plastic Field Boxes :-** They are strong & durable. They are usually made from moulded polyvinylchloride, polypropylene or polyethylene. They have smooth surface which does not damage the produce & they

are easily cleaned. They are expensive to buy initially but can be used repeatedly.

6. **Pallet Boxes :-** They are usually from wood but plastic ones are also available. They are used for whole range of crops which are commonly loaded in to them in the field & them transported directly to the store.
7. **Fibre Board Boxes :-** These are made from either laminated or corrugated fibre board. They may be used for transporting produce from the field to the pack house. Boxes are also made of mixtures of fibre board and plywood or hardboard. The season for these mixtures is either of reduce the cost of the box or to make it lighter & more durable.

Modified Atmosphere Packaging :-

It is used in the storage of fresh fruits & vegetables, the term refers of their storage in plastic film which restrict the transmission of respiratory gases. This Results in the accumulation of carbon dioxide & depletion of oxygen around the crop, which may increase their storage life.

The actual concentration of gases in the crop will also be affected to a limited degree by the amount of space between it & the plastic film, but mainly by the permeability of the film. This is affected by chemical properties of the film, its thickness, temp. & humidity. The changes in the atmosphere inside the sealed plastic film bag depends on the characterstics of the material used to make the package, the environment inside & outside the package as well as the respiration of the produce it contains.