AIM : **To perform gram staining of given sample.**

MATERIAL REQUIRED : Glass slides, bunsan burner , cotton , sample , microscope.

REAGENTS REQUIRED: Crystal violet dye, iodine, alcohol (95% ethyl alcohol), saffranin dye

PRINCIPLE: Gram staining is most widely staining technique used in m/o examination. It was discovered by Danish scientist and physician Hans Christain Joachin Gram in 1884. This technique differentiates bacteria in 2 groups i.e. Gram positive and Gram negative bacteria. The procedure is based on the ability of m/o to retain colour of the stain during Gram reaction. Gram negative bacteria are decolourised by alcohol losing the colour of primary stain , purple. Gram positive bacteria are not decolourised by alcohol and will remain as purple. After decolourisation stop , a counter stain is used to impart pink colour to the gram negative m/o.

Gram positive bacteria have a thick mesh like cell wall which is made up of peptidoglycan (50-90%) of cell wall, which stain purple. Gram negative bacteria have a thinner layer of peptidoglycan (10% of cell wall) and lose the crystal violet iodine complex during decolourisation with alcohol rinse but retain the counter stain safarin thus appearing reddish or purple.

STAIN REACTION :

1. **Application of crystal violet to heat fixed smear :**
   CV dissociates in aqueous solution into CV^+ and Cl^- ions. These two penetrate the cell wall and cell membrane of both gram positive and gram negative . CV^+ interact with negative component of bacterial cell and stain it purple.

2. **Addition of gram iodine :**
   Iodine acts as a mordant and a trapping agent. A mordant is a substance that increase the affinity of cell wall for a stain by binding to primary stain , thus forming a insoluble complex that get trapped in cell. During the reaction CV-I compex is formed and all the cells turn purple.

3. **Decolourization with ethyl alcohol** :
   Alcohol dissolve the lipid outer membrane of gram negative bacteria, thus leaving the petidoglycan layer exposed and increase the porosity of cell wall. The CV-I complex is then washed away from the peptidoglycan layer leaving gram negative bacteria colourless.In gram positive bacteria , alcohol has dehydrating effect on cell wall causing cell wall to shrink , then CV-I complex get tightly bound into multi layered leaving the cell with purple colour.

4. **Counter stain with safranin dye** :
   The decolourised gram negative cell can be visible with a suitable counter stain which is usually positively charged safarnin, which stained it pink.

PROCEDURE :1. Prepared very thin smear of sample on glass slide and heat fixed it.

2. Flooded the smeared slide with crystal violet dye. Avoid over flooding and kept it for 1 minute.

3. Washed the slide under running tap water.

4. Applied iodine solution gently all over the slide and kept for 1 minute.

5. Washed it under tap water.

6. Applied 95% ethyl alcohol all over the slide drop wise and kept for 10 second.

7. Immediately rinsed with water.

8. Finally, flooded the sample with saffranin dye to counter stain and kept for 45 seconds.

9. Washed the slide with running water.

10. Observed it under microscope.

Aim:- To study the sterilization of equipments used in laboratory by using heat & chemicals.

Theory:- Micro organisms are present in nature and they can contaminate everything. It must be assumed that all exposed surfaces including wash tubes, hand glassware and instruments are likely to be contaminated by free floating microbes which settle down on every exposed material. The principle technique is to remove or kill micro org. that are present on equipments. Adequate care must be taken to prevent the entry of any contaminating substances growing in the environment. Various suitable treatments must be adopted to kill these micro org. These are:

- Sterilization: It means elimination of all microbes .
- Antiseptic: It means prevention of proliferation of microbes and prevention of introduction of viable microbes.
- Disinfection: It means reduction in the no. of viable micro org.

Various methods which are used for the purpose of sterilization are:

HEAT STERILIZATION:

Moist heat sterilization

Autoclave: it is the most common method of sterilization. IT works at a time-temp. combo of 121 degree C at 15 psi for 15 mins, to kill all forms of micro org using steam under pressure. It is double jacketed steam container maintained at particular time temp. combination.

Tyndaliization: It involves 3 successive steam treatments, to achieve sterilization over the cause of 3 days. This work by killing the vegetative cell and spores before they get time to form further spores, but if any spore survive from 1st treatment, it will get killed in 3rd sterilization cycle.

i. Boiling in water: Boiling at 100 degree C for 30 mins is done in water bath. Syringes , rubber goods, surgical instruments may be sterilized by this method.
ii. Steaming: It is done by steam sterilization which works at 100 degree c under normal atm pressure .

Dry Heat Sterilization:

Flaming: is done to loops and straight wires until they glow red which ensures that any infectious agents i.e. present gets inactivated . However during initial heating infectious material may be separated from wire before it gets killed and hence contaminating the nearly surfaces and objects, so dip the wire or loop in 70 percent ethanol, it kills many bacteria before placing it on flame.

Hot air Oven: Glass wares, swab sticks, syringes, powder and oily substance are sterilized using hot air oven.

CHEMICAL STERILIZATION: a variety of non volatile, non toxic chemicals are used in laboratory to disinfect glass wares, hands etc. These includes

a. Halogen and halogen compounds
b. Compounds of heavy metals
c. Phenols and its derivatives
d. Alcohol and detergents

Examples:

a. Mercuric chloride and AgNO3: are used in the ratio of 1:100 resp. , for disinfecting surface of test material.
b. Ethyl Alcohol : used for disinfecting surface of test material & laboratory desktop.

GASEOUS STERILIZATION:

Ethylene Oxide: it is most commonly used to sterilize objects sensitive to temp. greater than 60 degree C. It is carried out b/w 30-60 ºC with RH above 30 % and gas conc. B/w 200-800—mg/L.

NO_2: It is used rapidly against wide range of micro org. including bacteria. Viruses and spores. It has a boiling point of 21º C which results in relatively high saturated vapour pressure coz of this liquid nitrogen may be used as a constituent source for sterilization.

Ozone: it is also used in some labs to sterilize water as well as disinfecting for surfaces.

Aim- To prepare culture media.

Requirements- Nutrient broth, Nutrient Agar, Distilled Water, Autoclave, flask etc.

Theory-

Culture medium or the growth medium ia s liquid or gel designed to support the growth of microbes. Most common media used for culturing the micro-organism is nutrient broth. When mixed with agar and poured in petri plates, it solidifies and provide solid medium for microbial cultures. It remains solid as very few micro-organisms are able to decompose agar. It contains all the nutrients required by micro-organisms and is non selective.

Nutrient broth consists of:

Composition	**g/l**
Peptones	5
NaCl	5
Yeast Extract	2
Beef Extract	1

13g of nutrient broth for 10 ml of media is added. It is dissolved in distilled water to prepare 1000ml of media only if it is available otherwise nutrient broth can be supplemented with 2% of agar- agar to prepare nutrient agar.

Procedure:

1- Weighed point 0.6g of nutrient broth and mixed with 50ml of distilled water.
2- Cotton plug the flask
3- 4.2g of nutrient agar was weighed and it was added to 150ml of distilled water. Again cotton plugs the flask.
4- Nutrient broth and agar was autoclaved at 121^0C for 15minutes at 15 psi pressure.
5- After autoclaving, the media was cooled to 45^0C.

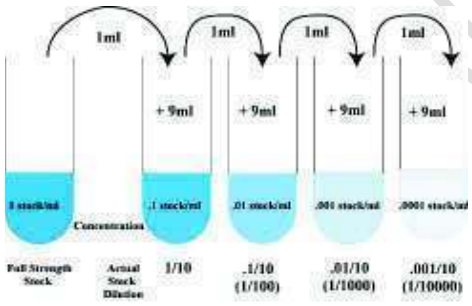
AIM-To prepare serial dilutions of sample and perform pour plate, spread plate & streak plate method for isolation and enumeration of micro-organism.

Requirements: Nutrient agar, petriplates, saline solution (0.85%), cotton plugs, micropipette, Laminar flow, etc.

Theory- The microbial population in our environment is diverse and contains species of bacteria, fungi, yeast and molds. The study of specific micro-organism for different purpose is very important. This requires the dilution of the sample initially for accurate enumeration in distilled water or saline solution. Then the micro-organism can be isolated using different isolation methods:

1. Streak plate technique.
2. Pour plate technique
3. Spread plate technique.

Procedure- <u>Preparation of serial dilution:</u>



1. Prepared saline solution (0.85%) and poured 9 ml of solution in 5 tests tube each.
2. Cotton plugged the tubes and autoclaved.
3. Prepared the stock solution with sample.
4. Under the aseptic conditions in laminar air flow, prepared the dilution with the sample upto 10^{-5}.
5. Different **<u>plating techniques</u>** were performed:

- **Streak plate technique:** By means of a transfer loop, a portion of the mixed culture is placed on the surface of an agar medium and streaked across the surface. The manipulation thins out the bacteria are separated from each other. When streaking is done properly the colonies grow sufficiently far apart showing no merge of colonies. The assumption is made that colony is derived from a single cell &therefore the colony is a clone.

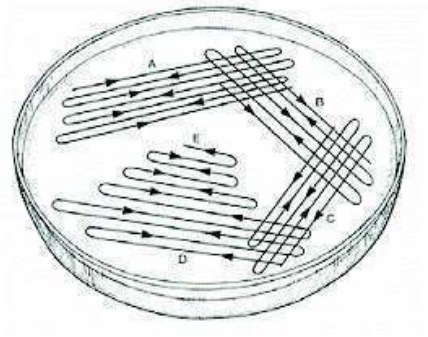


Fig: Method of Quadrant streak

- **Pour plate technique:** In this mixed culture is diluted directly in tubes of liquid agar medium. The medium is made liquid state at a temperature of 45^0C to allow thorough distribution of the inoculums. The inoculated medium is dispensed into petri-dishes, allowed to solidify and then incubated.

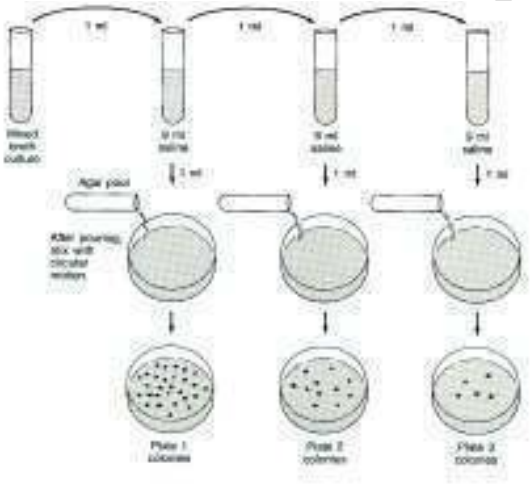


Fig: Pour plate technique

- **Spread-plate method:** The mixed culture is not diluted in the culture medium instead it is diluted in a series of tubes containing a sterile liquid. A sample is removed from each tube, placed onto the surface of an agar plate by means of bent glass rod. One plate of the series bacteria will be in numbers sufficiently low as to allow the development of well separated colonies.

Fig: Spreading Method

AIM: To study the presence of Vibrio cholera in given sample of water (gol gappa)

REQUIREMENTS: MacConkey agar, petriplates, test tubes, autoclave, etc,.

THEORY: ***Vibrio cholerae*** is a Gram-negative, comma-shaped bacterium. Some strains of *V. cholerae* cause the disease cholera. Cholera infections are most commonly acquired from drinking water in which *V. cholerae* is found naturally or into which it has been introduced from the feces of an infected person. Other common vehicles include contaminated fish and shellfish, produce, or leftover cooked grains that have not been properly reheated. *V. cholerae* thrives in water ecology, particularly surface water. The primary connection between humans and pathogenic strains is through water, particularly in economically reduced areas that don't have good water purification systems.

PROCEDURE:

1. Prepare MacConkey agar and autoclaved it.
2. Prepare the serial dilution of the sample upto 10^{-3}.
3. Perform pour plating, spreading and streaking techniques for the isolation and enumeration of the bacteria using MacConkey agar.
4. Observed for the pinkish red coloured colonies.

AIM: To study microbiology of given fruit product.

REQUIREMENTS: MacConkey agar, Nutrient agar, Potato Dextrose agar, petriplates, diluted sample.

THEORY: It is estimated one-fourth of the harvested fruits and vegetables is spoiled before consumption. Spoilage of fresh fruits and vegetables usually occurs during storage and transport. Vegetables and fruits reach the consumer as fresh, dried, frozen, fermented, pasteurized, or canned. Contamination may take place during harvesting, handling, transportation or storage unless proper hygienic conditions were not maintained. Mechanical damage may increase the susceptibility to decay and the growth of microorganisms may take place. Washing process in contaminated water may moisten surfaces enough to permit entry and growth of organisms. Storage in contaminated containers, use of contaminated dressing materials, and possible contact with decayed products, unhygienic handling, fly infestation etc. will also cause an accelerated rate of spoilage. Contamination in the raw material will adversely affect the quality of finished product. The deterioration of raw vegetables and fruits may result from physical factors, action of their enzymes, microbial action, or combinations of all these. Microbial spoilage in fruits and vegetables varies not only with the kind of fruit or vegetables but also to some extent with the variety. The composition of the fruit or vegetable influences the likely type of spoilage. Thus, bacterial soft rot is widespread for the most part among the vegetables, which are not very acid. Because most fruits and vegetables are somewhat acid, are fairly dry at surface. Thus the character of the spoilage will depend the product attacked and the attacking organism.

PROCEDURE:

1. Prepare the serial dilution of the sample (10^{-3}).
2. Prepare the MacConkey agar, Nutrient agar and PDA and autoclave it.
3. Perform the pour plating technique with all the media for the isolation of different microbes (Bacteria, yeast and molds).
4. Incubate the plates at 25C (PDA) and at 35-37C (MacConkey and Nutrient agar).
5. Observed for the growth of microbial colonies.

AIM: Qualitative analysis of Milk by MBRT (Methylene Blue Reduction Test).

REQUIREMENTS: Milk sample, Methylene blue dye, test tubes, etc.

PRINCIPLE: Milk is a good medium for the growth of microorganism. A variety of microorganism can be found in both raw milk and pasteurized milk. These actively growing microorganisms reduce the oxidation reduction potential of the milk medium due to the exhausted oxygen by the microorganism. Normally the milk is contaminated with microorganisms such as *Staphylococcus aureus*, *Streptococcus pyogenes*,*Pseudomonas aeroginosa*, *Enterobacter spp*., *Bacillus spp*., *Paenibacillus spp*., etc.

The principle of methylene blue reduction test depends on the fact that the color imparted to the milk by adding a dye such as methylene blue will disappear more or less quickly, which depends on the quality of the milk sample to be examined. Methylene blue is a redox indicator, that lose its color under the absence of oxygen and is thought to be reduced. The depletion of oxygen in the milk is due to the production of reducing substances in the milk due to the enhanced rate of bacterial metabolism. The dye reduction time refers to the microbial load in the milk and the total metabolic reactions of the microorganism.

METHYLENE BLUE REDUCTION TIME (HOUR)	**GRADE OF MILK**
5 h or more	excellent
Between 4-5h	Very good
Between 3-4h	good
Between 3-2h	fair
Less than 2h	poor

PROCEDURE:

1. Transfer 10 ml of each milk sample into appropriately labeled test tube.
2. Add 1 ml of redox indicator, methylene blue to each test tube containing milk sample.
3. Tighten the test tube mouth with stoppers. Gently invert the tubes at about four or five times to ensure proper mixing of the methylene blue solution.
4. Keep the tubes in the water bath at 37 ^{o}C
5. Note the incubation time. That is, the time elapsed for the color to turn whitish appearance.
6. Stabilize the tubes for 5 minutes.

AIM: To perform endospore staining.

REQUIREMENTS: Malachite green dye, soil sample, saffranin dye, slide, etc.

THEORY: Vegetative cells are bacteria that are actively growing, metabolizing and dividing. When vegetative cells are subjected to environmental stresses such as nutrient deprivation they eventually die. Endospores are dormant or metabolically inactive forms of a bacterium that allow it to survive the harsh environmental conditions. Spores are resistant to heat, UV radiation and chemicals because they are comprised of a tough proteinaceous covering called keratin. A mature endospore contains a complete set of the genetic material (DNA) from the vegetative cell, ribosome and specialized enzymes.
A differential staining technique (the Schaeffer-Fulton method) is used to distinguish between the vegetative cells and the endospores. A primary stain (malachite green) is used to stain the endospores. Because endospores have a keratin covering and resist staining, the malachite green will be forced into the endospores by heating. In this technique heating acts as a mordant. Water is used to decolorize the cells; as the endospores are resistant to staining, the endospores are equally resistant to de-staining and will retain the primary dye while the vegetative cells will lose the stain. The addition of a counterstain or secondary stain (safranin) is used to stain the decolorized vegetative cells. When visualized under microscopy the cells should have three characteristics: the vegetative cells should appear pink, the vegetative cells that contain endospores should stain pink while the spores should be seen as green ellipses within the cells. Mature, free endospores should not be associated with the vegetative bacteria and should be seen as green ellipses.

PROCEDURE:

1. Prepare the serial dilution of the soil sample (10^{-2})
2. Take the diluted sample on the slide and make the smear of it.
3. Heat fix it for 5 min.
4. Put Malachite green dye on the smear and again heat fix it for 2-3 min.
5. Allow it to cool and wash it under running tap water.
6. Air dry the slide.
7. Put saffranin dye on the slide and keep it aside for 2min.
8. Again wash the slide and dry it.
9. Observe under the microscope for the appearance of pink coloured vegetative cells and green coloured matured endospores.

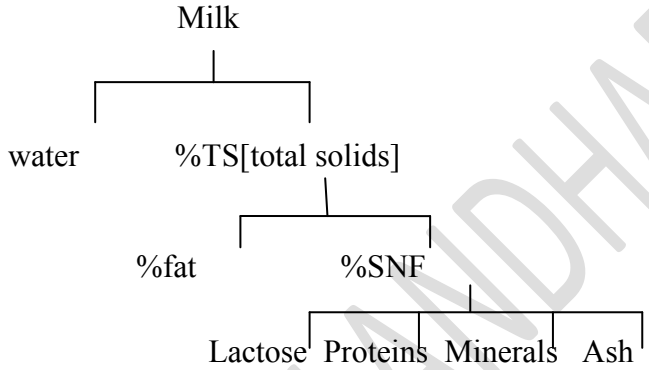
FST-302 Fluid Milk Processing

EXPERIMENT NO- 1

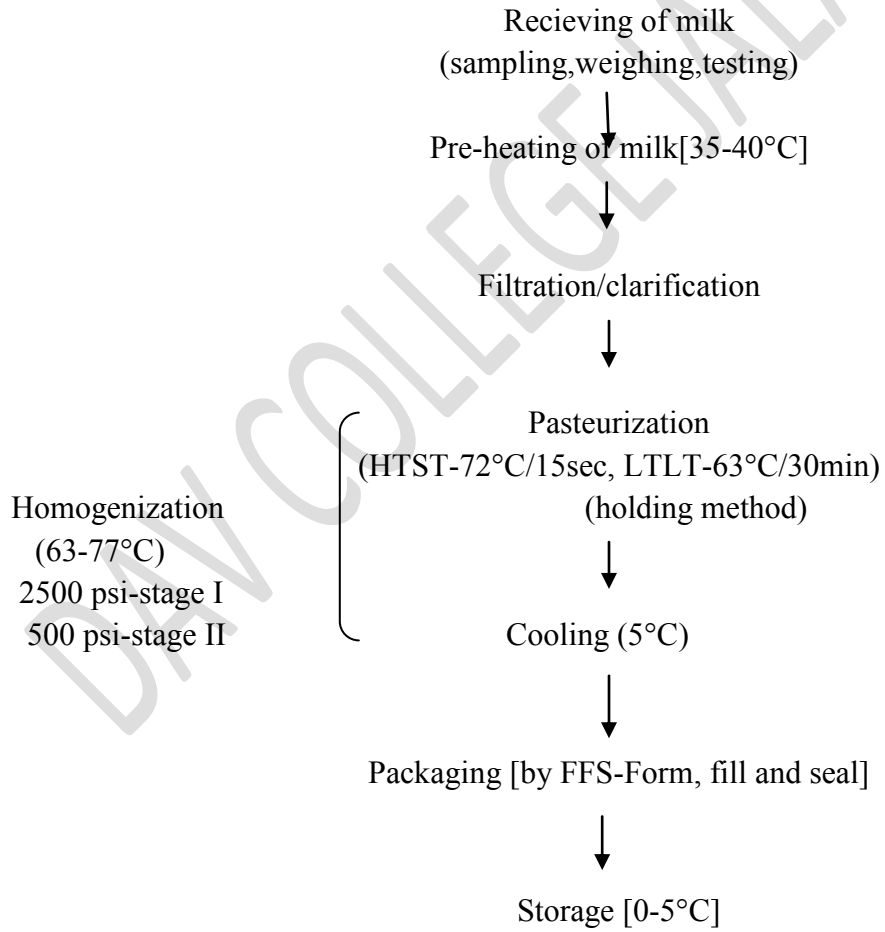
Aim: To study processing of milk and various appliances used for sampling of milk

Defination of milk: - Milk is a clean , fresh , whole lacteal secretion obtained by milking of one or more healthy milch animals .

Composition of milk:



Processing of milk: -



SAMPLING OF MILK: - It should be carried out in an accurate manner & the sample collected should represent the chemical & bacteriological quality of milk. Precautions should be taken that

the stirrer, sample, container should be properly sterilized before taking the representative sample.

APPLIANCES FOR SAMPLING: -

1. Plunger, 2. Sampling Dipper, 3. Sampling Bottles

These appliances should be preferably made up of stainless steel. They should be capable of withstanding a sterilization temperature of 121°C for 15 min at 12 psi.

1. PLUNGER: - Plunger should have sufficient area to produce adequate distribution of the product. It should be light in weight for operation to move it rapidly in liquid milk. A plunger recommended for mixing consist of a disc i.e 150mm in diameter. The disc is centrally fixed to a metal rod & the other end of it forms a loop handle. The length of a handle including the rod is 1m.

2. SAMPLING DIPPER: - It should be fitted with a solid handle atleast 150mm long. The capacity of the sampling dipper should not be less than 80ml. The dipper handle is bent over the upper corner. The body of the sampling dipper should be made up of a single metal with no sharp corner.

3. SAMPLING BOTTLE: - They are made up of good quality glass i.e suitable for sterlization. The capacity of glass bottle should be between 150-200 ml. The size of the sampling bottle should be such that the quantity of sample taken should not leave enough space to cause churning of the milk sample. When the sample is collected for bacteriological purposes it is desirable to fill the bottle upto the brim to avoid air space at the top of the bottle.

MILK SAMPLING TECHNIQUES: - Milk sampling should always be done by experienced person. All precautions should be taken to prevent any sort of contamination when milk is sample for chemical and bacteriological analysis. The sampling equipments used should be properly sterilized, clean and dry for bacteriological examination.

1. Sampling from individual container: - When milk is draw from an individual container the mixing is done with the help of a plunger and the plunger is moved in such a way that it ensures through agitation of milk. Then sample is drawn with the help of a sampling dipper.

2. Sampling from several containers: - Pour the milk from one container to another and then the sample is taken from one container.

3. Sampling from bulk units:-When milk of uniform quality is supplied in bulk units, then sampling is done randomly.

LABLING OF SAMPLES: - Each sample container should be sealed air fight after filling and then worked with particular regarding the purpose of suppliers, the time of sampling, the test which has to be carried out.

Sampling for chemical analysis: - If the sample is to be analyzed chemically it should be immediately brought to chilled temperature and the chilled temperature should be maintained until it is analyzed.

Sampling for microbial analysis: - If the sample is to be microbiologically analyzed it should be store and maintained at a temperature not more than 4°C. If the time interval between the sampling and examination exceeds more than 4 hours then it should be mentioned on the label. Normally the microbial analysis should be carried out within 4 hours of the sampling.

EXPERIMENT NO. 2

AIM: - To calculate specific gravity, % SNF and T.S in a given milk sample

REQUIREMENTS: - Water bath, measuring cylinder, beaker, and lactometer

PROCEDURE: -

1. Heat the given milk sample to 40°C
2. Cool the milk sample to 29°C.
3. Fill the milk in measuring cylinder upto the brim and take care that no air bubbles should be present.
4. Dip the lactometer in the measuring cylinder and take care that it should not touch the sides of the measuring cylinder.
5. The lactometer will float in the cylinder containing milk. Lactometer reading is taken correspondence to the upper meniscus of the milk.

GENERAL CALCULATIONS: -

1. Specific gravity

Specific gravity= 1+CLR/1000

where CLR is corrected lactometer reading.

2. % SNF [solid not fat]

% SNF = CLR/4 + 0.2 X F + 0.72

where F = % fat in milk , CLR = corrected lactometer reading , 0.72 = constant

3. % T.S [total solids]

% T.S = CLR/4 + 1.2 X F + 0.72

Experiment- 3

Aim: To study the various platform tests conducted in a dairy industry for acceptance of raw milk.

PRINCIPLE: Milk is tested for its quality at the receiving platform in order to ensure that good quality of milk is received. The tests are performed to ensure that inferior quality of milk doesn't get mixed with superior or high quality of milk. These tests are named as Platform Tests because they are performed at receiving platform with an objective to decide whether to reject or accept the milk before their chemical analysis is done in quality control lab. These tests are performed in all dairy industries and only an experienced person can pick out the bad sample with accuracy.

1. **Organoleptic test:** all the cans are smelled to check any foul smell and rejecting that can thereafter. Then, observe the colour of the milk and if the colour is formed to be abnormal, the milk should be rejected immediately. After this the milk is tested and examined for following Odours or flavours.

(i) Acidic odour: It is due to the development of acidity.
(ii) Feedy odour: It is due to the feed given to the cattle exposure of milk to atmosphere.
(iii) Foreign odour: It is due to the presence of foreign matter which might have entered the milk during or after milking.
(iv) Oxidised odour: It is sue to the exposure of milk to light or metallic containers. (Cu or Fe)

2. **Lactometer Reading:**

REQUIREMENTS: Water Bath, Measuring Cylinder beaker, lactometer.
PROCEDURE:
1. Heat the given milk sample to 40 degree C.
2. Cool the milk sample to 29 degree C.
3. Fill the milk in measuring cylinder up to the brim and take care that no air bubbles should be present.
4. Dip the lactometer in the measuring cylinder up to the brim and take care that it should not touch the sides of the measuring cylinder.
5. The Lactometer will float in the cylinder containing milk. Lactometer reading is taken correspondent to the upper meniscus of the milk.

3. Determination of % acidity of milk:
REQUIREMENTS: Milk sample, burette and beaker
CHEMICALS REQUIRED: 0.1 N NaOH, Phenolphthalein
PROCEDURE:
1. Rinse the beaker with the milk sample.
2. Pipette out 10mL of milk in the beaker.
3. Add 2-3 drops of phenolphthalein indicator to it.
4. Titrate the contents against standard alkali soln. (0.1 N NaOH) to a light pink colour end point.

FORMULA USED (% lactic acid):
% titrable acidity= 90*V*N*100/W*1000
Where 90= molecular wt. of lactic acid
V= volume of alkali used
N= normality of NaOH
W=weight of sample taken

4. Heat stability test:
REQUIREMENTS: test tubes, milk sample, water bath
CHEMICALS REQUIRED: 75% ethyl alcohol
A.) Alcohol Test:
PROCEDURE:
1. Take about 5mL of milk sample in a test tube.
2. Add equal amounts of ethyl alcohol and mix the contents by inverting the test tube several times.
3. The presence of clots on flakes confirms the alcohol test.

B.) COB Test (Clot on Boiling)

PROCEDURE:
1. Take 5 mL of milk in a test tube.
2. Place the test tube in a boiling water bath.
3. Remove the test tube from water bath and check for any clots or flakes formation.
4. A positive COB test is indicated by formation of clots or flakes.

Experiment-4

AIM: Determination of percentage fat in milk [Gerber's centrifuge]

REQUIREMNTS: Butyrometer, 1mL pipette, 10mL pipette, milk pipette (10.75mL), stopper, Gerber centrifuge, milk sample.

CHEMICALS REQUIRED: 90% H_2SO_4, Amyl alcohol

PRINCIPLE: Definite quantity of H_2SO_4 and Amyl Alcohol is added to a specific volume of milk (10.75mL). The acid will cause the breakdown of oil in water emulsion causing the denaturation of proteins and in turn cause the fat globules to set free. The fat globules will remain in liquid state and upon centrifugation; it will separate to the top under the effect of Amyl Alcohol.

PROCEDURE:

1. Heat the milk to 40 degree C.
2. Add 10 mL of 90% H_2SO_4 to butyrometer.
3. Pipette out 10.75mL of milk in the butyrometer along its sided using milk pipette.
4. To this, add 1 ml of amyl alcohol & few drops of water.
5. Lock the butyrometer using lock stopper.
6. Shake the contents and place the butyrometer in Gerber centrifuge. Run the centrifuge for 2-3 minutes.
7. Note down the readings and calculate % fat in it.

Experiment-5

AIM: To check the suitability of milk sample for thermal processing.

REQUIREMENTS: Test tubes, Milk Sample, Water Bath

CHEMICALS REQUIRED: 75% Ethyl Alcohol

PRINCIPLE: Milk is tested for its quality at the receiving platform, so that only good quality of milk is received. Tests are conducted to ensure that inferior quality of milk doesn't get mixed with high quality of milk, two tests are conducted.

I. ALCOHOL TEST
II. COB TEST (CLOT ON BOLING)

I. ALCOHOL TEST: This is carried out to check the heat stability of milk. It is a useful indicator of mineral balance of milk. This test helps in detecting abnormal milk such as colostrum & mastitis.

PROCEDURE:

1. Take about 5 mL of milk sample in a test tube.
2. Add equal amount of ethyl alcohol and mix the contents by inverting the test tubes several time
3. The presence of flakes or clots confirms the alcohol test.

INTERPRETATION OF RESULT: A positive alcohol test indicates that the milk has high acidity and it is not suitable for Thermal processing.

II.COB TEST: This test is conducted to determine the heat stability of milk or to check the suitability of milk for thermal processing.

PROCEDURE:

1. Take 5 mL of milk in a test tube.
2. Place the test tube in boiling water bath for 5 minutes.
3. Remove the test tube from water bath and check the test tube for any clot or flake formation.
4. A positive COB test is indicated by formation of clots or flakes.

INTERPRETATION OF RESULT: Milk Sample with positive COB test has acidity more than 0.17% and therefore the milk is not suitable for thermal processing. But milk with negative test is suitable for thermal processing.

Experiment-6

Aim: To detect the presence of glucose in milk.

REQUIREMENTS: Adulteration is generally done for financial gains either by removal of fat or any other useful component of milk by addition of inferior materials in milk. Glucose is added to make the determination of Total solids more difficult.

APPARATUS: Beaker, boiling water bath, Fehling solution A, Fehling Solution B

PROCEDURE:
1. Take 10 mL of milk sample in a beaker and add 5mL each of Fehling Solution A and Fehling Solution B.
2. Mix the contents well.
3. Heat the contents in Boiling Water bath for 5 minutes and allow it to cool.
4. Appearance of reddish brown colour indicates presence of glucose in milk.

Experiment-7

AIM: To detect the presence of urea in milk.

THEORY: Adulteration is generally done for financial gains either by removal of fat or any other useful component of milk or by addition of inferior material in milk. Urea is added to make the determination of total solids more difficult.

A.) TCA TEST (Trichloro acetic acid)

Chemicals required: 2% Hypochlorite solution, 5 % Phenol Solution, and 25% TCA.

APPARATUS REQUIRED: Boiling Water Bath, Whatman No. 42 filter paper, test tubes, funnel and beakers.

PROCEDURE:

1. Take 5mL of milk sample in a flask.
2. Add 5 mL of TCA solution to it.
3. Mix the contents and filter it through whatman no. 42 filter paper.
4. Collect the filtrate and to 1 mL of filtrate add 5mL of Hypochlorite solution.
5. Mix the contents thoroughly and add 0.5 mL of 5% phenol solution.
6. Note down the colour of solution. A typical blue or bluish green colour indicates the presence of urea in milk.

B.) RAPID TEST:

APPARATUS: beakers, milk, soya powder.

PROCEDURE:

1. Take 5mL of milk in a beaker and heat it to 27 degree C.
2. Add 1g of soya powder to milk sample.
3. Mix the contents thoroughly and allow it to stand at room temperature for 10 minutes.
4. Note down the pH of the mixture with the help of pH paper.
5. If pH is more than &.5, it confirms the presence of urea in milk.

Experiment-8

AIM: To detect the presence of neutralizers in a given milk sample.

A. <u>ROSALIC ACID TEST</u>:

REQUIREMENTS: test tubes, beaker, pipettes

CHEMICALS REQUIRED: 95% ETHYL ALCOHOL AND ROSOLIC ACID.

PRINCIPLE: Rosalic acid develop rose red colour upon reaction with carbonates and bicarbonates and give light brown colour upon reaction with pure milk.

PROCEDURE:
1. Take about 10mL of milk in a test tube.
2. Add 10 mL of 95% ethyl alcohol.
3. Shake the contents thoroughly.
4. Add 2-3 drops of rosalic acid solution and observe the colour.

B. <u>DETERMINATION OF TESTING ACIDITY OF ASH</u> :

APPARATUS: Silica crucible, muffle furnace, pipettes.

REAGENTS: 0.1N NaOH, phenolphthalein indicator

PROCEDURE:
1. Pipette out 20mL of milk in a clean and already weighed silica crucible and evaporate the milk to dryness by heating on hot plate.
2. Cool the contents at room temperature and then keep the crucible in muffle furnace at 550 degree C for 5-6 hours until a grayish white ash is obtained.
3. Cool the contents at room temperature and weigh the crucible.
4. Transfer the contents to clean beaker with 10mL distilled water along with continuous sorting with a glass rod.
5. Titrate the contents with standard acid solution using phenolphthalein as indicator.

Experiment-9

AIM: Detection of mastitis milk.

THEORY: Mastitis or infection of udder is caused by certain species of Streptococcus & Staphylococci. Although, it is caused by non-pathogenic bacteria but still this type of infection interfere with efficient secretion of milk & therefore it is necessary to examine the milk regularly. This test is based upon the fact that milk obtained from inspected animals will be usually alkaline and show pH as high as 7.4.

REQUIREMENTS: beakers, test tubes.

CHEMICALS REQUIRED: Bromothymol blue

PROCEDURE:
1. Take 5mL of milk sample in a test tube and add 1mL of bromothymol blue solution.
2. Mix and observe the colour.
3. If the colour changes from straw yellow to blue, then the milk is obtained from the animal infected with mastitis.

Experiment-10

AIM: To determine the pH of given milk sample.

REQUIREMENTS: pH paper, pH meter, beakers, test tubes and milk sample.

PRINCIPLE: pH is defined as negative log of hydrogen ion (H^+) or in other words, it is a measure of acidity of milk. Generally, pH decreases with increase in acidity and low pH is indicator of development of acidity of milk sample. On other hand, pH value of milk from an animal suffering from mastitis will be more than 7. pH of milk can be determined by pH paper or pH meter.

PROCEDURE:

(i) By using pH Paper:

1. Take a pH indicator strip and dip in the sample and observe the change in colour.
2. The strip is then dried and change in colour is compared with colour given on the main strip.

(ii) By using pH meter:

PROCEDURE:

1. The surface of pH meter is dipped carefully in pH 4.0 buffer in 100mL of distilled water.
2. Take care that bottom of electrode does not touch the bottom of beaker as the electrode is very sensitive to breakage.
3. Note down the pH and if it is not right, set it by using pH screen.
4. Now, take out the electrode from the buffer solution of pH and clean with distilled water and again wipe the surface with the filter paper.
5. Dip the electrode in buffer solution of pH 9.0 which is prepared by dissolving 1 buffer tablet of pH 9.0 in 100mL of distilled water.
6. Calibrate the pH with buffer solution 9.0
7. Now take out the electrode from the buffer solution of pH 9.0. Clean it with distilled water.
8. Dip the electrode in Milk Sample and note down its pH.

FST – 303 PROCESSING OF MEAT & MEAT PRODUCTS

Aim-To measure freshness of meat.

Requirements-Comminuted meat, pH meter, distilled water, NaCl, water bath, centrifuge, autoclave, Whatman no.42 filter paper, measuring cylinder.

Procedure-

A) Organoleptic test-The most useful test to determine extent of freshness of meat is to smell it and record the presence of any off-flavor. meat is smelled for any of following defects-

1) Putrid smell-It is characteristic of meat spoilage by microbial action.

2) sour odor-It is characteristic of spoilage by lactic acid bacteria.

3) Rancid flavor-It is characterized by due to spoilage by oxidation of fat.

But to measure freshness of meat objectively various tests performed. Some of these are discussed below-

1) WHC-Weigh about 50 g of ground meat in round bottom flask and add 22.5 ml of 0.6N NaCl sol. Stirr the content for 1 min. and let it stand for 15 min at 4 C. Again stir the content for 1 min and incubate at 4 C for 15 min. Centrifuge contents for 15 min and measure the supernatant and retained amount of water retained by meat as water holding capacity in ml per100g of meat.

2) Cook release volume-Cook meat in constant temperature in water bath at 80 C for 20 min by keeping it in a polythene bag. Calculate vol. loss during cooking subtracting loss of weight of cooked meat from weight of fresh meat and results are expressed as %CRV.

3) Extract release volume-Weigh out 25g of minced meat and temper it at 32C for 15 min. Then blend it with 100ml distilled water for 2 min. Then filter the slurry through Whatman no.42 filter paper and collect the filtrate and report the vol of filtrate and %ERV.

4) pH and acidity-Take about 20 g of minced meat in beaker and mix it with 50 ml distilled water. pH can be noted directly by dipping a calibrated pH meter in the sample. After pH determination titre of the sol with standard alkali using phenolphthalein as indicator.

5) Sensory evaluation-Cook meat for 10 min at 7 psi pressure and judge sensory quality products on hedonic scale. The grading of meat can be done as under-

1) Color-Color can be graded as excellent, very good or fair, dull.

2) Flavor-Flavor can be graded as fresh, rancid, putrid, metallic or stale flavor.

3) Juiciness-Meat can vary from juicy to dry

4) Tenderness-It can be defined as woody, tough and tender, soft or mushy.

Aim-Preparation of tandoori chicken.

Recipe-Chicken-680g

Curd-204g

Vinegar-1 cup

Chilly sauce-2 ts

Chat masala- 2 ts

Black pepper- taste

Salt- taste

Garam masala-2 ts

Turmeric- 2.99g

Observations-

Color-Golden brown

Flavor- Good

Tenderness- Soft

Juiciness-Little

Overall acceptability-Good

Theory-Tandoori chicken is highly accepted in the Indian cooking system which is prepared from tender chicken and is in India. The demand is in high nutrients in it and is usually served hot.

Procedure-1)Take dressed chicken, remove skin, neck and other fatty portion. Stretch the body of chicken by 3-4cm to flatten it.

2)Then make small cuts in the chicken surface for proper penetration of mixture of spices.

3)Then weigh the chicken and also spices. Then apply the mixture and salt and lime on surface and keep for 30 minutes.

4)Then pass the chicken through rods and pass through tandoor which is previously heated to 250-300 C for 15-20 minutes.

Aim-To prepare chicken pickle.

Recipe-

Chicken- 1 kg

Ginger paste- 50g

Garlic paste-50g

Red chili powder-5 g

Turmeric-5g

Salt-20g

Mustard oil-500ml

Hing-2g

Onion-200g

Black cardamom-20g

Saunf-20g

Black cumin seeds-10g

Vinegar-40ml.

Requirements-Chicken meat. heating source, heating pan, ladle, spices etc.

Procedure-Take chicken remove its skin, debone it and cut into 1\2 inch pieces. Then mix red chillies, turmeric and salt with half of ginger and garlic paste. Rub the chicken with marinated and keep aside for half hour. Heat the oil in pan to smoke point then reduce the flame to medium heat and deep fry chicken pieces for about 5-7 min. Remove the chicken and strain oil and hing. Stir for 15 sec add onion and deep fry till color turns golden brown. Add remaining ginger and garlic paste and stir for a min and add vinegar and bring it to boil. Add the fried chicken. Cook the flame and cool. Then transfer content of pan to dry glass jar. Mature the pickle in warm place.

Aim:- slaughtering and dressing of poultry.

Requirements:- Slaughtering knife, boiling water pan, thermometer etc.

Theory:- Slaughtering and dressing is an important step in conversion of live animals to the meat. Method of slaughtering varies in different reasons, religion, places etc. Jhatka method is commonly used in India for slaughtering. In this method the head of animal is separated from rest of the body from neck with single stroke of knife. This method of slaughtering is considered humane because it does not causes much pain to bird to be slaughtering.

Procedure:- first of all, weight the live chicken and follow following procedure for its slaughtering.

1). Slaughtering:- the bird is slaughtered by using Jhatka method where head of the animal is separated from body by single stroke of knife. Cutting from neck through the jugular vein allows the animal to bleed completely.

2). Scalding:- After complete bleeding, the animal is dipped in hot water at a temperature of 80c for 2 minutes. Scalding is done to facilitate feather removal.

3). De-feathering:- Feathers are then removed by hand picking method.

4). Singeing:- Small hair feathers remaining on the body of bird are removed by burning on a direct flame. Flame is passed over carcass in such a way that only feathers are burnt, but no damage is caused to skin.

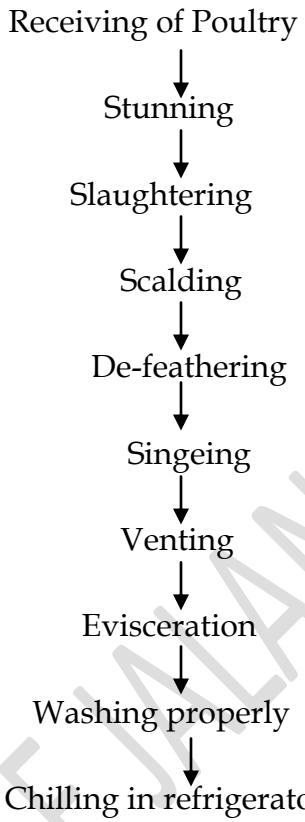
5). Venting:- back portion of bird near anus is pressed to remove any facial matter from the body carefully without any contamination of the carcass then oil gland of the bird is removed which is present at the tip of the tail.

6). Evisceration:- A cut is given below the breast bone to expose the body viscera. Intestine is cut along cloacae opening and knot is given to it. Whole of the viscera is removed except gizzard. The gizzard is incised, cut open, washed out and yellow epithelial layer is removed and washed. Shanks are removed from the carcass. Rest of the carcass is washed properly and weight is noted down. This is known as hot carcass weight. This type of poultry is known as New York dressed poultry.

7). Cut Up Poultry:- Here the carcass is cut into two back pieces, two legs, two wings, two breast pieces, one neck pieces and giblets.

Finally, carcass is washed properly with the water before being sent for chilling in the freezer.

Flow Chart



AIM: TO PREPARE CHICKEN PATTIES.

REQUIREMENTS: Spices, chicken, oil, pan, burner.

THEORY: The comminuted chicken products have been stimulated in recent years of success of new deboning equipment and technique for fabricating chicken muscles. It offers greatly success and scope for development of chicken.

PROCEDURE: 1. The deboned chicken meat is ground in food processor.

2. The ingredients as per recipe are mixed into meat.

3. The mixture is moulded, fried in oil till brown color is obtained and sensory evaluation is done.

RECIPE: Chicken- 1000g, Oil- 140g , Salt- 18g, Pepper- 7g, Cardamom- 2g , Onion- 2.5g, Garlic- 12g, Ginger- 38g , Maida- 30g, Sodium nitrate- 0.3g , Chilled water-40ml, Egg.

AIM: TO PREPARE CHICKEN BURGER .

REQUIREMENTS: Chicken patties, barbecue mayonnaise, tomato sauce, lettuce leaf, onions .

THEORY: Chicken based snack foods are becoming common these days. One of the reasons for success of fast food chains like KFC and MC DONALDS is their chicken burger. This burger can assembled easily and can be made interesting by using variety of ingredients. These products are healthy and liked by children especially.

PROCEDURE:

1. Take a burger bun and heat it on tawa with butter.
2. Then place lettuce leaf, onions, chicken patties on the burger bun.
3. Apply tomato sauce and mayonnaise on it.
4. Serve chicken burger hot with sauce.

AIM: PREPARATION OF SAUSAGES.

REQUIREMENTS: Onions, garlic, ginger, salt, potassium nitrite, sugar, ascorbic acid , sodium hexa meta phosphate, knife, blender etc.

PRINCIPLE: Sausages are one of the comminuted meat product which are quite famous in western countries. Different types of sausages are prepared and consumed in the world. These sausages are different from each other in extent of comminution, spices, herbs, casings etc. Further these sausages can be raw/ smoked/ cooked etc.

PROCEDURE: 1. Debone meat and mix all the ingredients.

2. Comminute the meat in blender.

3. Then stuff the mixture in casings using stuffer.

4. Cook the sausages in boiling water and serve hot with sauce.

RECIPE: Meat- 500g, Salt- 20g, Sugar- 2 tea spoon, Pepper- 5g, KMO2- 20mg, Ascorbic acid- 50mg, Onion- 50mg, Garlic- 10g, Ginger-10g, Sodium hexa meta phosphate- 2g.

FLOW SHEET: Debone meat > Mince the mixture > Mix all the ingredients > Blending > Stuffing into casings > Cooking.

FST – 304 (Post Harvest Management of Fruits & Vegetables)

List of Practical:

1. Study of the maturity indices of fruits and vegetables
2. To analyze the maturity stages of fruits
3. To analyze the maturity stages of vegetables
4. To study pre-cooling of fruits and vegetables
5. To study pre-packing of fruits and vegetables
6. To study storage of fruits and vegetables
7. To study controlled atmospheric storage of fruits and vegetables
8. To study ripening of fruits and vegetables
9. Study of spoilage of fruits and vegetables

Experiment # 1

Aim: Study of the maturity indices of fruits and vegetables.

Theory: Maturity of Fruits and Vegetables refers to the attainment of final stage of biological function by a plant part or plant as a whole or it is the particular stage in life of plant of fruit at which they attain maximum growth and size.

Good quality of fruits and vegetables are obtained when harvesting is done at the proper stage of maturity. It is the stage where any organ of the plant attains full growth and development. After maturity of any organ it starts its decline stage i.e. called as "Ripening". Earlier the harvest, longer is the time of ripen. Greater the maturity, lesser are the number of days required for the fruit ripen.

Types of Maturity of Fruits and Vegetables

A) Harvesting Maturity
B) Physiological Maturity
C) Commercial or Horticultural Maturity

Harvesting Maturity: The harvest maturity of vegetable depends upon the purposes for which it is harvested. For local market and for processing, fully colored fruits are harvested. However, for a distant market fruit which have started developing color are harvested.

Physiological Maturity: In a physiological sense, maturity refers to the attainment of final stage of biological function by a plant part of plant as a whole. For example, a French bean pod of okra is at its physiological maturity when seeds are fully developed and the pod will break with little pressure. It is judged by measuring rate of respiration and sugar: acid ratio. It always followed by senescence.

Commercial or Horticultural Maturity: It is the stage of development, when plant or plant part possesses the pre-requisites for utilization by consumer for particular purpose. It is a stage of fruit and vegetable at which consumer wants the fruit and vegetable or fruit and vegetable require by market.

Maturity Indices: The maturity indices are also called as "Maturity Standards" or "Signs of Maturity". These are important for deciding when a given commodity should be harvested to provide marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer. This is based on experience, skill and judgment. There are five types of indices to judge the maturity of the fruit.

- Visual indices: Shape, Size, Skin color, Aroma, Leaf change
- Physical indices: Abscission (easy separation), Firmness, Specific gravity
- Chemical indices: Soluble Solids Content (SSC), Titratable acidity, Juice content, Oil content, Sugars, Starch content
- Computation indices: Calendar Date, Heat units
- Physiological indices

Visual Indices:

a. **Shape**: The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops on the plant. Mangoes also change shape during maturation.

b. **Size**: Size is generally of limited value as a maturity index in fruit, though it is widely used for many vegetables. Size is often specified as a quality standard. Generally, large size indicate over-maturity and under-sized indicate an immature state. However, this assumption is not always a reliable guide for all-purpose. For example, partially mature cobs of *Zea mays saccharata* are marketed as sweet corn, while even less mature and thus smaller cobs are marketed as baby corn.

c. **Skin Color**: This factor is commonly applied to fruits, since skin color changes as fruit ripens or matures. The loss of green color of many fruits is a valuable guide to maturity. Color charts are available for cultivars, such as apples, tomatoes, peaches, chilli, peppers, etc.

d. **Aroma:** Most fruits synthesize volatile chemicals as they ripen. These may give the fruit its characteristic odor and can be used to determine whether a fruit is ripe or not. These odors may only be detectable to human senses when a fruit is completely ripe.

e. Leaf changes: This is a characteristic that is used in both fruit and vegetables to determine when they should be harvested. In many root crops the condition of the leaves can indicate the condition of the crop below ground.

Physical indices

a. Abscission: As part of the natural development of fruit, an abscission layer is formed. This can be judged by gently pulling the fruit. However, fruit harvested at this maturity will be well advanced and have only a short marketable life.

b. **Firmness***:* As fruit mature and ripen, they soften by dissolution of the middle lamella of the cell walls. The degree of firmness can be estimated by finger or thumb pressure, but more precise method involves the use of pressure tester or penetrometer.

c. **Specific Gravity***:* As fruit mature, their specific gravity increases. This parameter is rarely used in practice to determine when to harvest a crop. However, it is used to grade crops into different maturities.

Chemical Indices:

a. **Soluble Solids Content (SSC)***:* Soluble solid content (SSC) also called total soluble solids (TSS), can be determined in a small sample of fruit juice using hand refractometer.

b. **Titratable Acidity***:* The acidity of many types of fruit changes during maturation and ripening. In many fruit acidity progressively reduces as the fruit matures on the tree. Normally acidity is not taken as a measurement of fruit maturity by itself. It is usually related to soluble solids i.e termed as ˚Brix : acid ratio.

c. **Juice Content:** The juice content of many fruits increases as the fruit matures on the tree. The juice volume is related to the original mass of juice, which is proportional to its maturity.

d. **Oil Content:** Oil content can be used to determine the maturity of fruits, such as avocados. According to the Agricultural Code in California, avocados at the time of harvest and at any time thereafter shall not contain in weight less than 8% oil per avocado, excluding skin and seed.

e. **Sugars:** The measurement of sugars in the fruit can provide an indication of the stage of ripeness or maturity of that fruit. Usually sugars are the soluble solids that are in the largest quantity in fruit, so measuring the soluble material in samples of the juice can give a reliable measure of its sugar content. This is done either with a refractometer.

f. **Starch Content:** Measurement of starch content is a reliable technique used to determine maturity in pear and apple cultivars as in these carbohydrates are accumulated in the form of starch during maturation.

Computation indices:

a. **Calendar Date***:* For perennial fruit crops grown in seasonal climate which are more or less uniform from year to year, calendar date for harvest is a reliable guide to commercial maturity. Time of flowering is largely dependent as temperature and the variation in number of days from flowering to harvest can be calculated for some commodities by use of degree-day concept. Such harvesting criteria can be developed by the growers based on their experiences.

b. **Heat Units**: An objective measure of the time required for the development of the fruit to maturity after flowering can be made by measuring the degree days or heat units in a particular environment. It has been found that a characteristics number of heat unit or degree-days are required to mature a crop. Usually, under warm conditions, maturity will be advanced and under cooler conditions, maturity is delayed.

Physiological Indices: The physiological methods (CO_2 and ethylene rates) have been successfully used as the most reliable methods to determine the optimum physiological state for the maturity of fruits.

Table 1. Maturity indices for selected fruits and vegetables

	Maturity Indices	Fruits/Vegetables
1.	Calendar date	All fruits
2.	DFFB	All fruits and radish
3.	Mean heat units	Apple, pear, grape, mango, ber, litchi and many vegetables
4.	T-Stage	Apple
5.	Size	All fruits, beans, carrot, cucumber, cherry, asparagus and cauliflower.
6.	Surface morphology	Grape (cuticle formation), banana and litchi.
7.	Specific gravity	Cherries, mango and ber.
8.	Fruit retention strength	Apple
9.	Colour (Surface) (Seed) (flesh)	All fruits, tomato and muskmelon Apple and pears Mango, papaya, watermelon and muskmelon
10.	TSS	All fruits and tomato and melons
11.	Firmness	Pome and stone fruits, beans, lettuce and muskmelon
12.	Juice content	Citrus.
13.	Acidity and Sugar/acid ratio	Pomegranate, citrus, papaya and kiwifruit
14.	TSS/acid ratio	Grape and citrus
15.	Sugars	Pome, stone fruits and grape
16.	Astringency (Tannin)	Persimmon and dates.
17.	Oil content	Avocado
18.	Respiration and Ethylene evolution rates	Apple and pears.

Abscission	Apple, Melon
Aroma	All fruits
Leaf changes	Root crops
Starch content	Pear, Apple

Experiment # 2

Aim: To analyze the maturity stages of fruits.

Theory: Maturity of fruits refers to the attachment of final stage of biological function by a plant part or plant as a whole or it is the particular stage in life of plant of fruit at which they attain maximum growth and size.

The maturity indices are also called as "Maturity Stages" or "Signs of Maturity". These are important for deciding when a given commodity should be harvested to provide marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer. This is based on experience, skill and judgment.

Maturity Signs of Fruits

Banana

1. The small bananas are ready for harvest within 11 to 14 months after planting while tall varieties take about 14 to 16 months to harvest.
2. Fruits usually mature in 120 to 140 days after flowering.
3. The fruit bunch is harvested when the ridges on their surface changes from angular to round.
4. The dried parts of flowers at the top of fruit drop off easily.
5. The top most leaf starts drying as the bunch matures.
6. Color of fruits or fingers changes from dark green to pale green.

Mango

1. Fruits generally require 95 to 115 days to mature after flowering.
2. Building of shoulders and a slight depression near the stalk end indicates the maturity of fruit.
3. Color of fruit changes from dark green to pale green.
4. Red blush develops on the fruit shoulders.
5. One or two or three ripe fruits fall from the plant naturally, indicating maturity of the other fruit on the tree.
6. The fruits with specific gravity between 1.00 to 1.02 are said to be mature.

Coconut

1. Coconut usually matures in about 350 to 375 days after appearance of the inflorescence.
2. Color of fruit changes from green to yellowish or brownish green.
3. The fruit produces peculiar metabolic sound on thumping.
4. All nuts in a bunch mature at the same time and uniformity.

Papaya

1. Fruits require 125 to 140 days from flowering to maturity.
2. Color of fruit changes from green to pale green or yellowish.
3. Portion of fruit exposed to sunlight becomes dark yellow in color.
4. The latex of fruits becomes watery.
5. T.S.S at harvest should be minimum 6%.

Ber

1. About 125 to 150 days are required for harvesting of fruits after flowering.
2. Color changes from green to pale green / red / brownish, yellow, depending upon variety.

3. Fruit become soft.
4. Specific gravity should be less than 1 with golden yellowish color.

Guava

1. Fruit mature in 140 to 160 days after flowering.
2. Color changes from green to pale green or yellow.
3. Fruit becomes soft.
4. A slight depression develops near the stalk end.
5. Ridges on the fruit disappears and it becomes round.

Grapes

1. A fruit mature in 120 to 135 days, after flowering.
2. Depending upon the variety, color changes from green to yellow on golden yellow or black or pink.
3. Being non – climacteric, fully ripe fruits are harvested.
4. Easy separation of barriers indicates harvesting stage.
5. Development of characteristics flavors and aroma.
6. Anabe shahi: 15 to 16 % T.S.S. Thompson seedless 18 to 20 % T.S.S.

Pomegranate

1. Fruits are ready for harvesting in about 150 to 170 days.
2. Color changes from green to yellow or yellowish brown.
3. Fruit becomes soft.
4. Ridges develop on the fruits and fruit becomes flat.
5. Floral part dry out.
6. Pressing fruit with finger give cracking or metallic sound.

Mandarin and Sweet Orange

1. Fruit mature in about 210 to 240 days.
2. Color changes from green to pale green or pale yellow or orange.
3. Outer rind looks shiny and one can see oil glands on the fruit.
4. Mandarin: 0.4% acidity and 12 to 14 % T.S.S; Orange: 0.3% acidity and 12% T.S.S.
5. Fruits become soft.

Kagzi Lime

Flowers mature in 120 to 150 days.

Water Melon

1. Size of the fruits and color of the rind are not good indicators.
2. Fruits are ready for harvest in 90 to 120 days from sowing.
3. Four criteria are commonly used in determining the maturity of the fruits:
   a) Withering of tendril: The tendril accompanying the fruit withers as fruit ripeness.
   b) Thumping: Ripe fruits when thumped with finger give out heavy dull sound, whereas the immature fruits give metallic sound.
   c) The portion of fruit, which rests on the ground, turned yellowing at maturity.
   d) Ripe fruits produce a crisp, cracking noise on being pressed with the flat of the hand.

Muskmelon

Fruits will be ready for picking in about 110 days depending upon variety. There are two groups of cultivars which behave distinctly. In one group, the fruits when mature slips out easily from

the vine with little pressure or jerk or if not it will remain separated from the vine next day. This is called full slip stage. In some Indian cultivars, green stripes on the skin begin to turn yellow during maturity.

Pineapple

1. Require 105 to 130 days for maturity.
2. Color of lower portion of fruit turns green yellow.
3. Eyes on the fruit becomes smooth or flat and they buldge on the sides.
4. Eye bracts become loose and turn brown in color.
5. Mature pineapple should have 12% T.S.S, 0.5 to 0.6% acidity and 0.98 to 1.02 specific gravity

Custard Apple

1. Require 100 to 120 days for full maturity.
2. Scales on fruits becomes prominent, plumy and well space.
3. Scales or segments turn creamy white.

Jamun

1. The seedling Jamum plants starts bearing after 8-10 years of planting, while grafted once after 6-7 years.
2. Color changes from green to deep purple or black with full size.

Maturity Indices for Selected Fruits

Fruits	**Maturity indices or characteristics**
Almonds	Splitting of hull, Separation of hull from shell, Development of abscission zone
Apple 'Golden Delicious' 'Red Delicious'	 12% SSC, 18 lb firmness 11% SSC, 18 lb firmness
Asian Pears	Skin color change from green to yellowish green
Banana	Disappearance of angularity in a cross section of the finger
Ber	Color break stage (when light yellow colour appear)
Grapes	SSC (%): 14 to 17.5 (min) depending on cultivars, SSC/TA: 20 or higher.
Guava	Color break stage (when skin color changes from dark green to light green)
Lemon	30% or more juice by volume
Lychee/litchi	TSS: Total acid ratio: 30-40, Color: Bright red
Kinnow	TSS/Acid ratio: 12:1 to 14:1
Kiwi fruit	TSS: 6.5%, Firmness: 14 lbs
Mango	Changes in shape : Increase fullness of cheeks or bulge of shoulder Flesh color: Yellow to yellowish-orange
Papaya	Skin shows yellowing
Peaches	Ground color change from green to yellow (varied for different cultivars)
Plums	Skin color changes
Pomegranate	TA: 1.85% (min.), Juice color: Red
Strawberries	2/3 of berry surface showing pink or red color
Watermelon	Flesh color: 75% Red, TSS : 10%
Melon	Ground color change to white with greenish tint, Slightly waxy peel.

Experiment # 3

Aim: To analyze the maturity stages of vegetables.

Theory: Maturity of vegetables refers to the attachment of final stage of biological function by a plant part or plant as a whole or it is the particular stage in life of plant of fruit at which they attain maximum growth and size.

The maturity indices are also called as "Maturity Stages" or "Signs of Maturity". These are important for deciding when a given commodity should be harvested to provide marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer. This is based on experience, skill and judgment.

Maturity Signs of Vegetables

Cabbage

1. At low elevations cabbage varieties mature in about 62 to 110 days from field setting and about 81 to 125 days at high elevations.
2. Solidity and firmness of head are the usual maturity characteristics used.
3. Head color turns a lighter shade of green when full development is a attained.
4. They have tendency to burst or loosen the leaves beyond the marketable stage.

Cauliflower

1. The best stage of maturity is determined by curd size and condition. Local growers usually harvest the head upon the desired size and before the curds become discolored, loose or otherwise blemished.
2. The head should be compact and not to be broken into segments.
3. Over mature head, becomes too long, flower stalks elongates resulting in loose, leafy condition and possess poor market value.

Knol-Khol

1. Harvesting is done when it attains its marketable size i.e. 5 to 7 cm in diameters and bright color depending upon variety.
2. At this stage the edible portion is tender and non-fibrous.

Tomato

Harvesting depends upon the purpose for which they are used. Four maturity stages are generally recognized.

a. Green stage: The mature green fruits are generally harvested to send them to the distant market.

b. Pink Stage: At this stage color turns to pink or red at the blossom end. They are picked for local market.

c. Ripe stage: At this stage surface of the most of the fruits is red and then soften of fruits begins.

d. Fully Ripe: At this stage fruits have approached maximum color development and are soft. Starch is changed into sugars. They are generally consumed or used for canning and processing.

Chilli

1. Chillies are harvested at two stages, one for green vegetables and the other as dry chillies.
2. Green Chillies are harvested when they are fully mature and before their color change from green to red.
3. Chillies for drying should be harvested when color changes from green to red.

Brinjal

1. The fruits must be harvested as soon as they have attained the desired size, color and before they lose their bright glossy appearances and become dull.
2. The fruits are edible from the time they are quarter growth until they are near ripe.

Carrot

1. Depending upon variety carrot become ready for harvesting within 100 to 120 days from sowing.
2. Depending on the variety, the desired size is the primary consideration in harvesting the roots.
3. Oversized roots are not acceptable.
4. Generally small to medium sized carrots are preferred.
5. At marketable stage carrots should have at least 2.5 to 4 cm diameter at the upper end.

Radish

1. European type is ready for harvesting within 30 days from sowing and Asiatic type within 45 to 60 days from sowing.
2. At this stage roots are mild, tender and crisp and usually of the proper marketable size.
3. Roots must be harvested before they become pithy, bitter and fibrous.

Onion

1. Harvesting depends upon the purpose for which the crop is planted and maturity will depend upon the variety being used.
2. Green Bunch Onion: Green onion is best when they are of lead pencil unit a small bulb is formed.
3. Ripe Bulbs: Ripe bulb crop is ready for harvest in 3 to 4 months after transplanting. Neck fall is the indication of maturity. The best time to harvest onion is when 60 to 70% of tops have broken over. Development of red pigment and the characteristics pungency of the variety are also important harvest indices.

Garlic

1. The crop may be harvested when the top turns yellowish or brownish and shows sings of drying up.
2. Crop gets ready for harvest in about 100 to 140 days after planting.

Bhendi

1. Fruits are harvested when the pods are still mature, young and tender. They are harvested at an interval of 2 to 3 days.
2. The best time of harvest being 6 to 7 days after opening of flower.
3. Mature pods are fibrous, tough, and ready for human consumption.

Pea

1. Early varieties require 45 to 60 days and late varieties require 70 to 100 days from sowing.

2. Peas must be picked up at the proper stage of maturity, because they start loosing their rapidly after reaching the edible stage.
3. Quality depends upon sugar content and tenderness. With increasing maturity and size, sugar content declines rapidly, with a correspondence increase in starch and protein.
4. High sugar content is indication of high quality.
5. Harvest the pods when color of pods changes from dark green to light green with good size.

Potato

1. Potatoes are harvested when they attain sufficient size. Early varieties 57 to 100 days, late varieties 120- 160 days.
2. Skin slipping from the tuber, starch content and leaf senescence or top drying are the harvest indices.

Cucumber

1. Fruits are ready for harvest 45 to 55 days after sowing.
2. Harvest immature fruits.
3. In cucumber the proper stage of maturity is judged by size and not by the age of the fruit.
4. Cucumber for slicing should be picked when they are 15 to 35 cm long, whereas for pickling 6 to 15 cm long. In case of slices at marketable stage, spines on fruit becomes soft and fall down.
5. In general, cucumber may be picked at any stage of fruit growth, provided yellowish has not started.

Sweet Potato

1. They are harvested 3.5 to 4 months after planting.
2. Leaves start yellowing
3. After cutting the tuber if white gum remains white, then they are ready for harvest, it turns blackish on green then tubers are said to be immature.

Leafy Vegetables (Spinach, Amaranthus and Fenugreek)

1. They are harvested 3 to 4 weeks after sowing,
2. Harvesting should be done, when the leaves are immature and tender, but large enough.
3. Old leaves are bitter and unfit for consumption.

Maturity Indices for Selected Vegetables

Vegetables	Maturity indices or characteristics
Beans	Pods are filled, Seeds immature.
Brinjal	Immature, Glossy skin, 40 days from flowering.
Cabbage	Firm head
Carrot	Immature, Roots reached adequate size.
Cauliflower	Mature and at least 6” in diameter, Compact
Cucumber	Immature and glossy skin
Garlic	Well filled bulbs, Tops dry down
Ginger	8-9 months after planting
Mushroom	Caps well rounded, Partial veil completely intact.
Okra	Pod 2-4” long, Not fibrous, Tips of pods pliable.
Onion (dry bulbs)	When 10-20% of tops fall over
Peas	Pods well filled but not faded in color.
Pepper	Fruit size and color (depends on color and intended market)

Potatoes	Harvest before vines die completely, Cure to heal surface wounds.
Radish (spring)	20 to 30 days after planting.
Radish (winter)	45 to 70 days after planting.
Tomatoes	Seeds fully developed, Gel formation advanced in at least one locule.

Experiment # 4

Aim: To study pre-cooling of fruits and vegetables

Theory: Pre-cooling is done to remove the field heat of the harvested produce, which is detrimental to keeping quality of fruits and vegetables and it is done to retard ripening and senescence processes. Prompt pre-cooling conserves the weight and extends the storage life in tomato. Physiological loss in weight (PLW) in storage can be reduced from 6 to 2.5% by employing pre-cooling treatments.

Methods of Pre-cooling: There are many methods of pre-cooling viz.

- Cold air (room cooling, forced air cooling)
- Cold water (hydro cooling)
- Direct contact with ice (contact icing)
- Evaporation of water from the produce (evaporative cooling, vacuum cooling)
- Combination of vacuum and hydro cooling (hydro-vac cooling)

Some chemicals (nutrients/growth regulators/fungicides) can also be mixed with water used in hydro cooling to prolong the shelf life by improving nutrient status of crop and preventing the spread of post harvest disease.

Air-cooling or Room Cooling: The use of refrigerated air as pre-cooling medium is widely used for pre-cooling packed fruit, but the system is not widely used for vegetables. Pre-cooling with air can be accomplished in a conventional cold storage room, a special pre-cooling room, or a forced air cooler. Cooling with air requires a longer time than cooling with water or vacuum.

Hydro Cooling: Cooling with cold water is rapid and effective method of pre-cooling. This method is used for cooling a wide range of fruits and vegetable in bulk before packing. Its use is limited for packed commodities because of the difficulty of achieving sufficient water flow through the containers. Flooding, spraying or immersion accomplishes hydro cooling. A properly designed flood system is more efficient than either the spray or immersion system because it combines a great volume of water with rapid movement of cooling medium over the product. When cooling completed, the product must be moved to a cold room.

Vacuum Cooling: Leafy vegetables are commonly cooled by reducing atmospheric pressure in artificial hermetically sealed chambers. Reducing the atmosphere pressure also reduces the pressure or water vapor in the chamber and thus cooling is effected. The outstanding advantages of vacuum cooling are the speed and uniformity of cooling of adapted commodities. Leafy vegetables, particularly lettuce is difficult to cool with water or air, but they can be field packed and then cooled quickly and uniformly by vacuum. Commodities like tomatoes with epidermis which is resistant to water movement are not adapted to vacuum cooling.

Top/Liquid/Package Icing: Icing is particularly effective on dense products and palletized packages that are difficult to cool with forced air. In top icing, crushed ice is added to the container over the top of the produce by hand or machine. However, as the ice comes in contact with the produce, it melts, and the cooling rate slows considerably. The ice keeps a high relative humidity around the product.

For liquid icing, slurry of water and ice is injected into produce packages through vents or handholds without removing the packages from pallets and opening their tops. Liquid icing distributes the ice throughout the container, achieving better contact with the product.

Package ice may be finely crushed ice, flake ice or slurry of ice. Packaged icing can be used only with water tolerant, non-chilling sensitive products and with water tolerant packages (waxed fiberboard, plastic or wood).

Icing methods work well with high-respiration commodities such as sweet corn and broccoli. One pound of ice will cool about three pounds of produce from 85ºF to 40ºF.

Pre-cooling of Fruits:

Temperature protection of the fruit in the field immediately after harvesting is very important. This can easily be done by moving the fruits to the shade. It is essential to remove the field heat of fruits in order to have extended shelf life.

Following Methods are adapted to Pre-cooling the Fruits:

i) Air Cooling: The air cooling is done by placing the fruits in the cold room. Fruits are placed in well ventilated containers in order to achieve some air exchange.

ii) Hydro-cooling: The hydro-cooling is an old and effective pre-cooling method for fruits. Fruits are dipped in cold water or spray the cold water on the fruits. Some chemicals are also mixed with water used in hydro-cooling to prevent the shade and diseases.

Hydro-cooling appears with a refrigerated $CaCl_2$ solution (21˚C for 10 minutes) would prevent storage disorders. Pre-cooling has got effect on quality of fruits e.g. L-49 variety of guava. The reducing sugar percentage and ascorbic acid content was higher in pre-cooled fruits than without pre-cooled fruits.

iii) Vacuum Cooling: It is costliest method of pre-cooling. It is rarely used in case of fruits. It is done by reducing the atmospheric pressure. It reduces the pressure of water vapor in chamber which results in evaporation of water from fruits which bring down the temperatures.

Pre-cooling of Vegetables:

When the vegetables are harvesting during hot weather, it is desirable to remove the filed heat of the harvested vegetables to retard the ripening and senescence. Cooling and storage losses can be reduced by pre-cooling. When the vegetable are harvested during hot period, pre-cooling is of vital importance e.g. melons.

Pre-cooling can be done by following processes:

i) Placing the vegetables in a refrigerated truck with forced humidified air circulation.
ii) Placing ice in package.
iii) Placing ice in water and passing the vegetables through a spray of cold water.
iv) Vacuum cooling is also done.
v) Hydro-cooling done by flooding, spraying or immersing is a rapid and effective method of pre-cooling.

Water is an excellent material to transfer a heat from the produce to the cooling medium. Highly perishable leafy vegetables and sealed crops are often cooled by reducing the atmospheric pressure.

Leafy vegetables are especially difficult to cool with and then cooled rapidly and uniformity by vacuum cooling. Asparagus cooled in water (0.5 to 1.0˚C) for 9 to 12 minutes and then stored at 2˚C for 1-5 days followed by 2 days at 20˚C reduces water losses and quality reduction during storage. Capsicum harvested at green when cooled in water at 7 to 10˚C for 10 minutes and then packed in poly bags with or without ventilation shows largest shelf-life than non-pre cooled one. Hydro cooling increases the storage life of melons when stored in 21% O_2 + 0% CO_2.

Recommended Pre-Cooling Methods for Vegetables

Vegetable	Pre-cooling method
Asparagus	Hydro-cooling, Package icing
Beans, snap	Room cooling, Forced-air cooling, Hydro-cooling
Beets	Room-cooling
Broccoli	Package icing, Forced-air cooling, Hydro-cooling
Brussel Sprouts	Hydro-cooling, Vacuum, Package icing
Cabbage	Room cooling, Forced-air cooling
Carrots	Package icing, Room cooling
Cauliflower	Hydro-cooling, Vacuum cooling
Chinese Cabbage	Hydro-cooling, Room cooling, Forced-air cooling
Corn, sweet	Hydro-cooling, Package icing, Vacuum
Cucumber	Forced-air cooling, Hydro-cooling
Eggplant	Room-cooling, Forced-air cooling
Garlic	No pre cooling needed
Greens	Hydro-cooling, Package icing, Vacuum
Herbs	Room-cooling
Lettuce	Hydro-cooling, Package icing
Melons	Hydro-cooling, Package icing, Forced-air cooling
Okra	Room-cooling, Forced-air cooling
Onions	No pre cooling needed
Onions, green	Hydro-cooling, Package icing
Oriental vegetables	Package icing
Peas	Forced-air cooling, Hydro-cooling
Peppers	Room-cooling, Forced-air cooling
Potato	Room-cooling, Forced-air cooling
Pumpkin	No pre cooling needed
Radish	Package icing
Rhubarb	Room cooling, Forced-air cooling
Rutabagas	Room cooling
Spinach	Hydro-cooling, Package icing
Squash, summer	Forced-air cooling, Room cooling
Squash, winter	No pre cooling needed
Sweet Potato	No pre cooling needed
Tomato	Room cooling, Forced-air cooling
Turnip	Room cooling, Hydro-cooling, Vacuum, Package icing

Recommended Pre-Cooling Methods of Fruits

Fruit	Pre-Cooling Methods
Apples	Room cooling, Forced-air cooling, Hydro-cooling
Apricots	Room cooling, Hydro-cooling
Berries	Room cooling, Forced-air cooling
Cherries	Hydro-cooling, Forced-air cooling
Grapes	Forced-air cooling
Nectarines	Forced-air cooling, Hydro-cooling
Peaches	Forced-air cooling, Hydro-cooling
Pears	Forced-air cooling, Room cooling, Hydro-cooling
Plums	Forced-air cooling, Hydro-cooling
Watermelon	No pre cooling needed

Experiment # 5

Aim: To study pre-packing of fruits and vegetables

Theory: Pre-packing is preparing fruits and vegetables for sale with minimum processing resulting in value addition and attracting a higher sales value.

This minimum processing also results in a "convenient" product that has minimal wastage and optimal quality for the consumer. Pre Packs are normally "portion specific" i.e targeted at a definite number of consumers e.g two portions, four portions, family portions. This is controlled through standardized weights and packages of the pre packed goods.

The minimal processing that products undergo for pre-packing renders the product "ready to use". Methods of processing include shredding, slicing, grating, cubing, chopping, whole cleaned top and tailed baby vegetables, topping and tailing, trimming, washing and spin drying e.g leafy vegetables and herbs, and portioning into florets e.g broccoli and cauliflower.

Hygiene is of outmost importance when value adding through processing or semi processing of vegetables and fruit and should be conducted in a clean custom designed processing area or facility.

Before commencing any processing, vegetables and fruits must be sorted and pre-washed with potable water free of any contaminants. All food handlers must follow a regime of good hygiene depending on the specific duty performed in the processing facility.

Pre-Pack Weights and Packaging

Pre-packed products are commonly referred to as convenient products, ready to use with minimal intervention. These products are more expensive than their raw material equivalents and consumers of these products are willing to spend a little more for the convenient aspect of the goods. Weights of pre-packed fresh products generally range between 100 - 500 grams for most products, though leafy vegetables and herbs may vary from 50 - 150 grams. To get accurate measures, it is wise to use a well calibrated electronic digital scale

Shredded vegetables are weighted to a standardized measurement and packed in either plastic bags or plastic punnets. The packaging is then sealed using a bar sealer or punnet lid that is securely taped down. The package must then be labeled showing all of the statutory requirements

Pre-Packed Articles

This refers to fruit and vegetables packed in advance of being offered for sale. They can be packed in bags, trays or any other kind of packaging.

If same pieces of whole fruits or vegetables are packed by count in transparent package then there is no need to mark the number on the package. Otherwise pre-packed fruits and vegetables must be marked with the correct measurement – either net weight or number. The marked weight cannot include the weight of any packaging or wrapping.

The statement of measurement must also be:

- clear to read, 2 mm from the edge of the principal display panel and at least 2 mm from other graphics
- in the same direction as the brand or product name
- in a different color from the background
- in metric units.

Note: The correct abbreviation for kilogram is 'kg' and for gram, 'g'.

If fruit and vegetables are packed in random weights, then mark each pack with the price/kg and total price. However, there is no need to mark the price/kg if pack contains the same article in constant sizes (e.g. if all packs of carrots are marked 600 g). Pre-packages must not contain less than the stated amount at all times prior to sale.

If the article is likely to lose weight over time through evaporation, dehydration or other means, the packer must make allowances for any expected losses in the measurement when packaging the product for the entirety of its shelf life.

Products packed at premises other than where they are sold must display the full name and street address of the packer, or the person for whom they were packed. The address given cannot be a post office box, an email address or phone number. The name and address of the packer must be clear and legible.

Pre-Packaging in Plastic Film

Pre-packaging increases the shelf life by create a modified atmosphere with an increases in concentration of CO_2 in the package. The packaging material used should provide reasonable access to oxygen. For this, beginning films like polystyrene and cellulose acetate are used. But together LDPE films which have high O_2 and CO_2 transpiration rates are more durable , the pouches must have perforation to transmit oxygen and carbon dioxide rapidly enough for the respiration of fresh produce. The pouch used reduces bruising facilitates inspection, reduces moisture loss and prevents dehydration. It also creates modified atmosphere.

In pre-packaging leaves, stalk, stem, etc. are trimmed washed cleaned and weighted quantities are put in pouches. Ethylene absorbents may be added to the package wherever required to retard the ripening process. Hydrated lime inserts may also be beneficial in controlling CO_2 concentration within the film package

Pre-Packed Baby Carrots

Pre-Packed Sweet Corn

Pre-Packed Garlic

Pre-Packed Spring Onions

Pre-Packed Mixed Salad Pack

Experiment # 6

Aim: To study storage of fruits and vegetables.

Theory: Fruits and vegetables are highly perishable in nature. To extend their post harvest availability, it is essential to store them under proper storage conditions. So as to increase the shelf life of fresh fruits and vegetables, they should be harvested at proper stage of maturity. Pre-cooling and post harvest treatments such as application of fungicides, bactericides, growth regulators, wax emulsions, ethylene absorbents, anti-transpirants, senescence retardants are also of almost importance to extend the marketable life of harvested horticultural commodities. There are different types of storage as briefly detailed below:

- **Ambient Temperature Storage:** Storage at room temperature.
- **Cold Storage:** Storage of the fruits and vegetables at the temperature lower than ambient temperature. The low temperature requirement varies from crop to crop. If the fresh fruits and vegetables are stored at the temperature below their optimum low requirement, develop chilling injury and therefore, loose the marketability. The fruits stored at low temperature exhibit more shelf life than those stored at ambient temperature.

The successful cold storage of fruit depends on a number of factors. Cold storage involves many physiological and biological problems. In the storage of fruits, it is always described to prolong ripening for as long as long possible and to delay the breaking down processes. Even after harvesting of the fruits the process of respiration continues and brings about ripening change in color, softening of flesh, increase in sugar content and development of flavor. These changes occur more rapidly at higher temperatures. This means that the lower the temperature of storage, the longer would be the storage life of the fruit but the fruit is disorganized resulting in physiological injuries such as development of pitting on the skin, change of color and internal breakdown.

Choice of Method for Storage of Fruits and Vegetables

Each method of storage has certain advantages and limitations over other methods. The choice of method will depend on number of considerations:

- Type of fruits or vegetables
- Variety
- Availability and cost of instrument
- Operation cost
- Technical man power

- Purpose of storage

Factors Influencing the Quality of Fruits in Storages: The factors influencing the quality of fruits in storages are:

1. Temperature: High temperature accelerates chemical and biological change and low temperature inhibits microbiological and chemical action responsible for decomposition.

2. Relative Humidity: If the humidity in storage chamber is too low, dehydration will result and the appearance of the fruit will be affected. If it is too high, condensation on fruit surface may take place which may encourage fungus growth. A relative humidity of 80 to 90 % has been found adequate for most of the fruits.

3. CO_2 Concentration: Higher concentration of CO_2 prevents ripening, may cause loss of color and flavor, and may increase rotting of fruits.

4. Microorganisms: Lower temperature retard the activity of microorganisms which usually settle down on the fruit surface and may bring about rotting. This is largely prevented by careful picking. Pre- storage treatments like washing with potassium permanganate solution and wrapping in paper may give good results.

5. The type of root stock, the age of trees, the type of soil, cultural treatment, the kind and variety of plant, the season of harvest, etc. also influence the storage quality of the fruits to a certain degree.

Results of Cold Storage Experiment in Fruits: The following are results of cold storage experiment carried out at the Ganesh Khind Fruit Experiment Station, Pune. (G.K.F.E.S, Pune).

1. Mango:

Green fruits of Alphonso picked when the shoulder have outgrowth the stem can be stored at 40˚F to 48˚F for 4 to 7 weeks. The ripe fruits cannot be presented in cold storage.

2. Santra**:**

Fully matured fruit which is just developing a tinge of yellow color develops uniform orange color and improve color and flavor of the juice when stored 52˚F for two weeks. After the fruits have assumed a fully ripe color, it can be stored a further period of 3 months without any deterioration in appearance of the fruit.

3. Mosambi**:**

Fruits can be stored at 52˚F for 3 months and for 5 months at 40˚F, but at lesser temperature there is no favorable change in color and there is also the possibility of the fruit developing a pitting of the skin which affects the market quality.

4. Malta**:**

The blood-red malta can be kept in good condition at 40˚F for 4 months without any deterioration. The bigger fruits are better suited for storage than smaller.

5. Lime**:**

Kagzi limes can be stored for two months at 52˚F they should be kept in partially closed tins. At lower temperature (40˚F) the fruits become chilled and begin to rot within 15 days.

6. Chiku**:**

Ripe fruit can be stored good condition for 6 weeks at 32˚F and 35˚F, unripe fruit becomes chilled below 52˚F but ripens satisfactory at 52 – 56˚F in five weeks.

Results of Cold Storage Experiment in Vegetables

1. Cauliflower**:**

Good sound cauliflower can be stored in cold storage for about a month at 30˚F with 85-90 % relative humidity.

2. Brussels Sprouts**:**

The sprouts keep well in storage at 32 to 34˚F temp and high humidity for 6-8 weeks.

3. Brinjal**:**

The harvested fruits can be kept for 7-10 days at 10˚F – 13˚F and 80-90 % relative humidity. Fruits can be stored in ordinary condition only for 2-3 days during winter and one to two days during summer season.

4. Tomato**:**

Mature green fruits may be stored at 10˚C – 14˚C for 30 days and ripe tomatoes at 4.5˚C for 10 days under 85-90 % relative humidity.

5. Pea**:**

Fresh unshelled peas may be kept for two weeks at 32˚F at relative humidity of 85-90 % peas can also be stored in crushed ice for about 2-3 weeks. The pods will freeze at 10˚C.

6. Radish**:**

Radish roots can be stored under ordinary conditions for 3-4 days, However under cold storage at 0˚C and 90-95 % relative humidity for about pods will freeze at 10˚C.

7. Potato**:**

Potato can be stored in the cold storage of the temperature of 34˚F- 37˚F and 90-95 % relative humidity.

8. Garlic**:**

Garlic bulbs along with their derived leaves are bunched and are hanged in well ventilated shade or room and can be stored for a longer period of time. The storage life of bulbs can be further increase in cold storage at 32-35˚F and 65-75% relative humidity. In cold storage bulbs without tops are kept in care or in gunny bags.

9. Fenugreek**:**

Green leaves are very perishable in nature. Therefore they are marketed soon after harvesting however well dried leaves can be stored for about 1 year.

The cold storage requirement and storage life of fruits and vegetables are given in **Table 1a and 1b**.

Table 1a: Cold Storage Requirement and Storage Life of Fruits:

S. No	Name of Fruit	Storage Temp (˚C)	R.H%	Approximate Life
1	Cashew apple	0-1.5	85-90	4-5 Weeks
2	Mangoes	7-9	85-90	4-7 Weeks
3	Oranges (Mosambi)	4-7	85-90	4 months
4	Pomegranate	0-1.5	80-95	4-6 weeks
5	Sapota	1.5-3.0	85-90	6-8 weeks

Table 1b: Cold Storage Requirement and Storage Life of Vegetables:

Sr.No	Name of Fruit	Storage Temp (˚C)	R.H%	Approximate Life
1	Cabbage	0 -2.5	90-95	3-4 month
2	Potato	0 -2.5	85-90	4 months
3	Peas	0 -2.5	85-90	1 -3 weeks
4	Okra	7.5	90-95	7-10 days
5	Tomato ripe	4.5-10	85-90	4-7 days

Storage Life of Fresh Fruits

Sr.No	Produce	Time (weeks) at Optimum Temp. -1 to 4˚C	Time (weeks) at Optimum Temp. 5-9˚C	Time (weeks) at Optimum Temp. 10˚C

Very perishable (0-4 weeks)				
1	Apricot	2	-	-
2	Banana (Ripe)			1-2
3	Banana(Green)			1-2
4	Berry Fruit	1-2		
5	Cherry	1-4		
6	Fig	2-3		
7	Loquat	1-2		
8	Mango		2-3	
9	Strawberry		2-3	
10	Watermelon		2-3	
Perishable (4-8 weeks)				
11	Avocado		3-5	
12	Grape	4-6		
13	Mandarin		4-6	
14	Nectarine	5-8		
15	Passion Fruit			3-5
16	Peach	2-6		
17	Pineapple (Ripe)		4-5	
18	Pineapple(Green)		4-5	
19	Plum	2-7		
Semi - perishable (6-12 weeks)				
20	Coconut	8-12		
21	Orange		6-12	
Non-perishable (>12 weeks)				
22	Apple	8-30		
23	Grape Fruit			12-16
24	Lemon			12-20
25	Pear	8-30		

Storage Life of Fresh Vegetables

Sr.No	**Produce**	**Time (weeks) at Optimum Temp. -1 to 4˚C**	**Time (weeks) at Optimum Temp. 5-9˚C**	**Time (weeks) at Optimum Temp. 10˚C**
Very Perishable (0-4 weeks)				
1	Asparagus	2-4		
2	Bean	1-3		
3	Broccoli	1-2		
4	Brussels sprout	2-4		
5	Cauliflower	2-4		
6	Cucumber		2-4	
7	Lettuce	1-3		
8	Pea	1-3		
9	Rhubarb	2-3		
10	Spinach	1-2		

11	Sweet corn	1-2		
12	Tomato		1-3	
13	Mushroom	2-3		
Perishable (4-8 Weeks)				
14	Cabbage	4-8		
15	Tomato (Coloured)			3-6
Semi-perishable(6-12 weeks)				
16	Cherry	6-10		
17	Leek	8-12		
Non -perishable (> 12 weeks)				
18	Beet root	12-20		
19	Carrot	12-20		
20	Onion	12-28		
21	Parsnip	12-20		
22	Pumpkin			12-24
23	Potato		16-24	
24	Sweet potato			16-24
25	Sweet turnip	16-24		

Experiment # 7

Aim: To study controlled atmospheric storage of fruits and vegetables.

Theory: Controlled atmosphere storage refers to keeping produce at decreased oxygen and increased carbon dioxide concentrations and at suitable range of temperature and RH. Systems where atmospheric control is accurately controlled are generally called CA storage.

The controlled atmosphere (CA) storage is one of the most significant contributions to the storage technology. When combined with refrigeration, it markedly retards the respiratory activity and may delay softening, yellowing, quality changes, and other deteriorative processes. However, important factor in CA storage is the tolerance or susceptibility of the fruits and vegetables to the injury caused by decreased O_2 and increased CO_2 concentration. The relative tolerance of individual fruits and vegetables varies considerably and is largely dependent on temperature, age, morphology and the anatomy of the horticultural products.

Controlled atmospheres are made of gastight chambers with insulated walls, ceiling, and floor. They are increasingly common for fruit storage at larger scale. Depending on the species and variety, various blends of O_2, CO_2, and N_2 are required. Low content O_2 atmospheres (0.8 to 1.5%), called ULO (Ultra -Low Oxygen) atmospheres, are used for fruits with long storage lives (e.g., apples).

Benefits of CA storage: The CA storage proves beneficial for fruits and vegetables that deteriorate rapidly or those that complete ripening after harvest. Different benefits are:

1. A considerable decrease in respiration rate, with a reduction in climacteric maximum, accompanied by an expansion of both pre-climacteric and post-climacteric periods.
2. A reduction in the effect of ethylene on metabolism due to the interaction of O_2 with ethylene, with a consequent delay of appearance of senescence symptoms.
3. An extension in storage life, which can even be doubled, in as much as the over ripening is delayed.

4. The preservation of an excellent firmness of flesh, due to effect of CO_2 concentration on the enzymes acting on cellular membranes.

5. A high turgidity is achieved, such that fruits are more juicy and crisp

6. A smaller loss of acidity, sugars and vitamin C, so that the nutritional and sensory quality is higher

7. A limited degradation of chlorophyll, with a consequent higher stability of color

8. Some physiological alterations, such as chill injuries, spot, decay, browning, water core and scald are prevented, or greatly limited

9. Moulds can be reduced, in particular under low O_2, high CO_2 atmospheres

10. A longer shelf life in the post storage trading due to the protraction of the effects on respiration and on the other metabolic activities.

Harmful effects of CA storage: Although CA storage is beneficial for extending the storage life of fruits and vegetables, it can also cause adverse effects such as:

1) Initiation or aggravation of certain physiological disorders can occur, such as blackheart in potatoes, brown stain on lettuce, and brown heart in apples and pears.

2) Irregular ripening of fruits, such as banana, mango, pear and tomato, can result from exposure to O_2 levels below 2% or CO_2 levels above 5% for more than 2 to 4 weeks.

3) Off- flavors and off-odors at very low O_2 or very high CO_2 concentration may develop as a result of anaerobic respiration and fermentative metabolism.

4) Accumulation of organic acids.

Hypobaric storage or Low-pressure system

Hypobaric storage is a form of controlled atmosphere storage in which the produce is stored in a partial vacuum. The vacuum chamber is vented continuously with water saturated air to maintain oxygen levels and to minimize water loss. Ripening of fruit is retarded by hypobaric storage, due to the reduction in the partial pressure of oxygen and for some fruits also to the reduction in the ethylene levels. A reduction in pressure of air to 0.1 atm is equivalent to reducing the oxygen concentration to about 2% at normal atmospheric pressure. There are two important considerations in developing and applying this technology to crop storage. Those are:

- The first is that the store needs to be designed to withstand low pressures without imploding. To overcome this, stores have to be strongly constructed of thick steel plate with a curved interior.
- The second is that the reduced pressure inside the store can result in rapid water loss from the crop. To overcome this, the air being introduced into the store must be saturated (100% R.H.); if it is less than this, serious dehydration of the crop can occur.

The hypobaric storage of fruits and vegetables combined with refrigeration increases the storage life to a considerable extent as compared to refrigeration storage alone. For example, when bananas were stored at 14°C, their storage life was 30 days at 760 mm Hg. But, when the pressure was reduced to 80 or 150 mm Hg, the fruit remained unripe for 120 days. The fruits were of very good texture, aroma and taste on subsequent ripening.

Hypobaric stores are expensive to construct because of the low internal pressures required, and this high cost of application appears to limit hypobaric storage to high value produce such as cut flowers. Secondly control of gases during the storage cannot be manipulated.

Recommended CA conditions for selected fruits and vegetables

Commodity	Temp. (°C)	% O_2	% CO_2
Apple	0-5	1-2	0-3

Banana*	12-16	2-5	2-5
Cherry, sweet	0-5	3-10	10-15
Mango*	10-15	3-7	5-8
Peach, clingstone	0-5	1-2	3-5
Pear, European	0-5	1-3	0-3
Asparagus	1-5	Air	10-14
Beans, green	5-10	2-3	4-7
Broccoli	0-5	1-2	5-10
Brussels sprouts	0-5	1-2	5-7
Cabbage	0-5	2-3	3-6
Cantaloupes	2-7	3-5	10-20
Cauliflower	0-5	2-3	3-4
Okra	7-12	Air	4-10
Onions (bulb)	0-5	1-2	0-10
Pepper (bell)	5-12	2-5	2-5
Radish (topped)	0-5	1-2	2-3
Tomatoes (green)	12-20	3-5	3-5
ripe	10-15	3-5	3-5

* CA is especially beneficial during transit

Experiment # 8

Aim: To study ripening of fruits and vegetables.

Theory: Ripening is the process by which fruits attain their desirable flavor, quality, color, palatable nature and other textural properties. Ripening is associated with change in composition *i.e.* conversion of starch to sugar. On the basis of ripening behavior, fruits are classified as:

1. Climacteric fruits
2. Non-climacteric fruits

Fruit ripening is a genetically programmed stage of development overlapping with senescence. The fruit is ripe when it attains its full flavor and aroma and other characteristics of the best fruit of that particular cultivar. The word "mature" and "ripe" are essentially synonymous when used to describe the fruits that ripe on the plants known as non-climacteric. However, in case of climacteric fruits, a mature fruit will require a ripening period before attaining a desirable stage of edibility.

Technologies for Ripening of Fruits

1. **Fruit Ripening using Calcium Carbide**

Most climacteric fruits especially banana and mango in India and many other developing countries are ripened with industrial grade calcium carbide. Calcium carbide releases acetylene and ethylene on interaction with moisture coming from fruits which act as artificial ripening agent.

Calcium carbide is cheaper than ethylene sources and easier to apply in simple ripening rooms. It is a by-product of the iron and steel industry and the material available contains impurities. The gas is released when the calcium carbide is exposed to moisture. The reaction can be violent, so the way it is commonly applied is to wrap small amounts (just a few grams) in twists of newspaper and put these among the bananas to be ripened. The high humidity reacts with the calcium carbide,

giving a slow release of acetylene. Where large quantities of acetylene are required quickly, the small amounts of calcium carbide can be dropped carefully into large buckets of water.

Great care must be exercised and the operator must wear protective clothing, including a protective face mask, and leave the area immediately. Hazard warnings should be put up and flames, cigarettes or electrical fittings that could cause a spark must be eliminated from the area.

But the use of this chemical for this purpose is illegal in most countries. In India too, use of calcium carbide is strictly banned as per **PFA (Prevention of Food Adulteration) Act [Section 44AA**] because of following reasons:

- Acetylene is believed to affect the nervous system by reducing oxygen supply to brain.
- Calcium carbide usually contains traces of arsenic and phosphorus which are toxic compounds and exposure may cause severe health hazards.

2. **Fruit Ripening using Ethephon/Ethrel**

Ethephon (2-choloroethyl-phosphonic acid) is commercially available and is registered for pre-harvest use on a variety of crops for controlling developmental processes or inducing ripening. This chemical is approved for post-harvest use on fruits crops for enhancing ripening. For post-harvest treatments, the known quantity of ethephon is diluted in water and fruits are dipped in the solution for a specified period. This substance ensures that there is uniform ripening of fruits. This technique provides a safe and effective method of ripening of fruits compared to the conventional technique of using calcium carbide.

3. **Fruit Ripening using Ethylene**

This is a safe and worldwide accepted method of ripening. Ethylene is a natural hormone for ripening when done under controlled temperature and relative humidity conditions.

Ethylene being a natural hormone does not pose any health hazard for consumers. It is a de-greening agent, which can turn the peel from green to perfect yellow (in the case of bananas) and maintain the sweetness and aroma of the fruit.

In this technique, the fruits are exposed to low level of ethylene gas (10-100ppm) in an air-tight ripening chamber for 24 to 72 hours so as to induce ripening. The most important thing in this technique is temperature and relative humidity control inside the ripening chamber, which should range between 15-25˚C and 90-95% relative humidity, depending upon the fruit type. Several methods used to provide proper ethylene concentration in the ripening room are:

- Gas Cylinders
- Shot system
- Ethylene generator

Method selected for applying ethylene depends on cost, convenience and safety factors.

Optimum storage and ripening temperatures for fruits

Commodity	**Ethylene conc. (ppm)**	**Ethylene exposure time (hr.)**	**Ripening temp. (˚C)**	**Storage Temp. (˚C)**
Avocado	10-100	12-48	15-18	4.4-13
Banana	100-150	24	15-18	13-14
Honey dew melon	100-150	18-24	20-25	7-10
Kiwifruit	10-100	12-24	0-20	0.5-0
Mango	100-150	12-24	20-22	13-14
Orange degreening	1-10	24-72	20-22	5-9
Stone fruit	10-100	12-72	13-25	-0.5-0

Optimal ripening conditions for fruit ripening

Temperature	18 to 25˚C
Relative humidity	90 to 95%
Ethylene concentration	10 to 100 ppm
Duration of treatment	24 to 74 hours depending on fruit type and stage of maturity
Air circulation	Sufficient to ensure distribution of ethylene within ripening room
Ventilation	Require adequate air exchange in order to prevent accumulation of O2, which reduces effectiveness of C2H4.

Classification of fruits and fruit vegetables based on climacteric and non-climacteric ripening patterns

	Climacteric	**Non-Climacteric**
Temperate Fruit	Apple Pear Peach Apricot Plum	Cherry Grape Strawberry
'Vegetable' Fruit	Melon Tomato Watermelon	Cucumber
Common Tropical Fruit	Avocado Banana Mango Papaya Fig Guava Passion fruit Persimmon	Orange Grapefruit Lemon Lime Olive Pineapple Litchi
Less Common Tropical Fruit	Cherimoya Soursop Breadfruit Jackfruit Mamey apple Sapota	Cashew apple Java plum Other Eugenia sp

Experiment # 9

Aim: Study of spoilage of fruits and vegetables

Theory: Food spoilage may be defined as any change that renders food unfit for human consumption. Every change in food that causes it to loose its desired quality and eventually becomes inedible is called food spoilage or rotting. These changes may be caused by various factors including physical and chemical changes such as the tearing of the plant or animal tissue or the oxidation of certain constituents of food may promote food spoilage. Food obtained from plant or animals sources begin to spoil soon after harvest or slaughter. The enzymes contained in the cells of plant and animal tissues may be released as a result of any mechanical damage inflicted during post harvest handling. These enzymes begin to breakdown the cellular material. The chemical reaction catalyzed by the enzymes result in the degradation of food quality, such as the development of off flavours, the deterioration of texture, and the loss of nutrients. The typical microorganisms that cause food spoilage are bacteria, yeast and molds.

Causes of spoilage: As soon as the fruits and vegetables are cut off from their natural nutrient supply, their quality begins to diminish. This is due to a natural process that starts as soon as the biological cycle is broken by harvesting. Once it is harvested, the agricultural product is edible for only a limited time, which can vary from a few days to weeks.

Types of spoilage:

1. physical spoilage
2. physiological ageing
3. spoilage due to insects or rodent
4. mechanical damage
5. chemical and enzymatic spoilage
6. microbial spoilage

Physical spoilage is caused by dehydration. Physiological ageing occurs as soon as the biological cycle through harvesting. Neither process can be prevented but they can be delayed by storing the agricultural products in a dry and draft free area at a low temperature as possible.

Insects and rodents can cause lot f damage, not only by eating the product but also by passing on microorganism through their hair droppings. The affected parts of the plants are the especially susceptible to diseases.

Chemical and enzymes spoilage occurs when especially when vegetables and fruits are damaged by falling or breaking. Such damage can release enzymes that trigger chemical reactions. Tomatoes can become soft and apple n other types of fruits turn brown. The fruit can also become rancid. The same processes can also be triggered by insects. The fruit become damaged which causes enzymes to be released. As soon as the peel of fruit is damaged by falling, crushing, cutting, peeling or cooking, the chances of spoilage increases considerably.

Prevention of spoilage:

To prevent harvested products from spoiling, they can be preserved. Physiological ageing and enzymatic changes are delayed or stopped. Microorganisms are stopped from multiplying on the product. Enzymes can be deactivated by heating the fruits and vegetables. The same effect can be achieved by making the fruit or vegetable sour or by drying them. The peel of a fruit or vegetable provides natural protection against microorganisms. To retain the desired quality of a product longer than if it were simply stored after harvesting, it must be preserved. To preserve food it must first be treated to stop physiological ageing and enzymatic changes and preventing the growth of microorganisms.

FST – 305 (Cereal Milling & Legumes)

List of Practical:

1. To study physical properties of wheat grains
2. To study physical properties of Rice grains
3. Determination of moisture content in a given sample of cereal grains
4. Determination of ash content in a given sample of cereal grains
5. To study cooking quality of rice
6. Study of wheat milling
7. Study of rice milling

Experiment # 1

Aim: To study physical properties of wheat grains

Requirements: Weighing Balance, measuring cylinder, beaker

Theory: Physical properties like weight, size and density are important criteria to determine the quality of wheat. The physical properties also help in designing various handling and storage devices. The various properties of wheat grain are:

1. **1000 kernel Weight**: It is an important property which is related to the endosperm content of the grain. The grain weight is affected by the size and density of the kernel. The diseased, shriveled and immature grains will have no grain weight. In case of wheat flour, recovery is directly correlated to grain weight. Endosperm to grain ratio is more in large grains. More will be the weight of 1000 kernels; more will be the quality of grains.
2. **Hectoliter Weight**: It is again the measurement of weight of wheat grain and related to endosperm content.
3. **Bulk Density**: It is defined as mass per unit volume and it gives idea about the space requirement for a given mass of grain. It also indicates purity of grains. Since the presence of light and foreign matter reduces the grain density.
4. **Angle of Repose**: Angle between the space and slope of cone formed due to free vertical fall of grains to the smooth horizontal surface is called angle of repose. It helps in pouring of grains and delivery of grains out from the storage place. It is important in construction of bulk storage facilities and in the calculation of dimension of intermediate holding bins of given capacity. Angle of repose depends upon size, shape, density of grain, roughness of grain, surface and height of fall of grains.
5. **Impurities (%):** It is the amount of impurities present in grain per 100 parts of grain. The various impurities present in grains are:
    a. Foreign matter: It includes the matter like straw, leaves, sand, dirt, clay, metal pieces etc.
    b. Shriveled grains: These are grains which are not fully developed and become shrivel due to loss of moisture content.
    c. Broken: It consists of pieces of grains that are less than $3/4^{th}$ the size of full grain.
    d. Weevilled grains: These are partially or wholly bored grains due to attack of weevils.
    e. Slightly damaged grains: It includes the grains with damaged pieces or discolored grains.
    f. Other food grains: Ant other food grains except wheat would be taken as impurity.

Procedure:

1. **1000 Kernel Weight:**
    a. Count 1000 grains of wheat.
    b. Take their weight by using weighing balance.
    c. Express the results as grams per 1000 grains.

2. **Hectoliter Weight:**
    a. Fill 1lt measuring cylinder with wheat grains along with tapping.
    b. Find out the weight of 1lt grains using weighing balance.
    c. Express the hectoliter weight as:

Hectoliter weight = weight of 1lt grains x 100

3. **Bulk Density:**
    a. Take a measuring cylinder of known volume.
    b. Fill the cylinder with wheat grains up to mark.
    c. Take the weight of grains filled in measuring cylinder.
    d. Calculate the bulk density as:

$$\text{Bulk density (g/ml)} = \text{mass/volume}$$

4. **Angle of Repose:**
    a. Take about 250gms of wheat grains free from impurity.
    b. Allow the free fall of grains from the container to a smooth surface.
    c. Measure the height of cone (H) and length of base (L).
    d. Calculate angle of repose as:

$$\tan\theta = H/D$$
$$\theta = \tan^{-1}(H/D)$$

Where,

$D = L/2$

θ = angle of repose

5. **Impurities (%):**
    a. Take 100gims of wheat grains.
    b. Separate all impurities from wheat grains.
    c. Take the weight of impurities.
    d. Calculate percentage of impurities as:

$$\text{Impurities (\%)} = \frac{\text{Weight of impurities x 100}}{\text{Weight of wheat grains}}$$

Experiment # 2

Aim: To study physical properties of rice grains

Requirements: Weighing Balance, measuring cylinder, beaker

Theory: Physical properties like weight, size and density are important criteria to determine the quality of rice. The physical properties also help in designing various handling and storage devices. The various properties of wheat grain are:

1. Length to Breadth Ratio: It is the ratio of length to breadth of a given rice grain which indicates the quality of rice as under:

S. No.	Type of Rice	L/B Ratio
1	Poor quality rice	Less than 2.5
2	Fine quality rice	2.5 – 3.0
3	Superior quality rice	More than 3.0

2. 1000 kernel Weight: It is an important property which is related to the endosperm content of the grain. The grain weight is affected by the size and density of the kernel. The diseased, shriveled and immature grains will have no grain weight. In case of rice flour, recovery is directly correlated to grain weight. Endosperm to grain ratio is more in large grains. More will be the weight of 1000 kernels; more will be the quality of grains.

3. Hectoliter Weight: It is again the measurement of weight of wheat grain and related to endosperm content.

4. Bulk Density: It is defined as mass per unit volume and it gives idea about the space requirement for a given mass of grain. It also indicates purity of grains. Since the presence of light and foreign matter reduces the grain density.

5. Angle of Repose: Angle between the space and slope of cone formed due to free vertical fall of grains to the smooth horizontal surface is called angle of repose. It helps in pouring of grains and delivery of grains out from the storage place. It is important in construction of bulk storage facilities and in the calculation of dimension of intermediate holding bins of given capacity. Angle of repose depends upon size, shape, density of grain, roughness of grain, surface and height of fall of grains.

6. Impurities (%): It is the amount of impurities present in grain per 100 parts of grain. The various impurities present in grains are:

g. Foreign matter: It includes the matter like straw, leaves, sand, dirt, clay, metal pieces etc.
h. Shriveled grains: These are grains which are not fully developed and become shrivel due to loss of moisture content.
i. Broken: It consists of pieces of grains that are less than $3/4^{th}$ the size of full grain.
j. Weevilled grains: These are partially or wholly bored grains due to attack of weevils.
k. Slightly damaged grains: It includes the grains with damaged pieces or discolored grains.
l. Other food grains: Ant other food grains except rice would be taken as impurity.

Procedure:

1. **Length to Breadth Ratio:**
   a. Take 10 grains.
   b. Arrange them length wise and note down the total length.

c. Arrange them breadth wise and note down the total breadth.
d. Calculate L/B ratio as:

L/B ratio = length of 10 rice grains/breadth of 10 rice grains

2. 1000 Kernel Weight:

a. Count 1000 grains of rice.
b. Take their weight by using weighing balance.
c. Express the results as grams per 1000 grains.

3. Hectoliter Weight:

a. Fill 1lt measuring cylinder with rice grains along with tapping.
b. Find out the weight of 1lt grains using weighing balance.
c. Express the hectoliter weight as:

Hectoliter weight = weight of 1lt grains x 100

4. Bulk Density:

a. Take a measuring cylinder of known volume.
b. Fill the cylinder with rice grains up to mark.
c. Take the weight of grains filled in measuring cylinder.
d. Calculate the bulk density as:

Bulk density (g/ml) = mass/volume

5. Angle of Repose:

a. Take about 250gms of rice grains free from impurity.
b. Allow the free fall of grains from the container to a smooth surface.
c. Measure the height of cone (H) and length of base (L).
d. Calculate angle of repose as:

$$\tan\theta = H/D$$
$$\theta = \tan^{-1}(H/D)$$

Where,

D = L/2

θ = angle of repose

6. Impurities (%):

e. Take 100gims of rice grains.
f. Separate all impurities from rice grains.
g. Take the weight of impurities.
h. Calculate percentage of impurities as:

$$\text{Impurities (\%)} = \frac{\text{Weight of impurities x 100}}{\text{Weight of wheat grains}}$$

Experiment # 3

Aim: Determination of moisture content in a given sample of cereal grains.

Requirements: Weighing Balance, Spatula, Hot Air Oven, Petri plates, Desiccator

Sample: Wheat grains, Rice grains

Theory: Moisture content is the amount of water present in cereal grains. It is one of the most important factors determining grain quality during harvesting, storage, trading, processing and transportation. Moisture content of cereal grains is a good indicator of grain storability. A moisture content of less than 14% is considered safe for storage of cereals.

The moisture content of wheat ranges from 8.0 – 17.0%. Wheat or wheat flour with high moisture content (more than 14.5%) attract mold, bacteria and insects, all of which causes deterioration during storage. Moisture content can be an indicator of profitability in milling. Flour is sold by weight and water is added to reach the standard moisture level before milling. The more water added, the more weight and profitability gained from wheat. However, wheat with too low moisture may require special equipment or process before milling.

The moisture content of rice ranges from 10.9 – 13.8%. Moisture content has significant influence on all aspects of paddy quality. To obtain high yield, it is necessary that paddy should be milled at the proper moisture level, which is 14%.

The moisture content of cereal grains is determined by oven drying method and physical methods. The oven drying method consists in measuring weight loss by foods due to evaporation of water. This method is generally used as it gives accurate results.

Procedure:

1. Take 5gms of sample in a clean, dry and pre-weighed Petri plate.
2. Put the Petri plate along with sample in a hot air oven at 130°C for a particular time (1hr).
3. After particular time, take out Petri plate from oven and place it in a desiccator for about 15mins to cool.
4. Then take the weight of Petri plate along with dry sample.
5. Calculate percentage moisture content as per formula.

Formula:

$$\text{Moisture Content (\%)} = \frac{\text{Weight of moisture content x 100}}{\text{Weight of sample}}$$

General Calculation:

Weight of empty Petri plate: W_1 (g)
Weight of Petri plate + Sample: W_2 (g)
Weight of Petri plate + Dry Sample: W_3 (g)

$$\text{Moisture Content (\%)} = \frac{(W_3 - W_2) \times 100}{(W_2 - W_1)}$$

Experiment # 4

Aim: Determination of ash content in a given sample of cereal grains.

Requirements: Weighing Balance, Spatula, Muffle Furnace, Silica Crucible, Desiccator

Sample: Wheat grains, Rice grains

Theory: Ash content of any food material is defined as any inorganic matter left after the incineration of organic matter present. The grain sample is first charred in a crucible so that organic matter gets carbonized completely and emerging gases escapes which otherwise deposit as black carbon on the surface of muffle furnace.

The ash content in wheat and flour has significance for milling. Millers need to know the overall mineral content of the wheat to achieve desired or specified ash levels in flour. Since, ash is primarily concentrated in bran; ash content in flour is indication of the yield that can be expected during milling.

Ash content also indicates milling performance by indirectly revealing the amount of bran contamination in flour. Ash in flour can affect color. It imparts a darker color to finished products. Some special products require white flour having low ash content while other products such as whole wheat flour have high ash content.

Ash content in wheat ranges from 1.5 – 2.0% and in rice 0.8 – 2.0%.

Procedure:

1. Take 2gms of ground sample in a clean, dry and pre-weighed crucible.
2. Burn all the organic matter by placing the crucible on direct flame until the smoke stops coming out from sample.
3. Put the crucible along with burned sample in a muffle furnace at 550°C for 6-8 hrs or until the grayish white residue is obtained.
4. After this, take out crucible from muffle furnace and place it in a desiccator for about 20mins to cool.
5. Then take the weight of crucible along with ash.
6. Calculate percentage ash content as per formula.

Formula:

$$\text{Ash Content (\%)} = \frac{\text{Weight of ash content x 100}}{\text{Weight of sample}}$$

General Calculation:

Weight of empty Crucible: W_1 (g)
Weight of Crucible + Sample: W_2 (g)
Weight of Crucible + Ash: W_3 (g)

$$\text{Ash Content (\%)} = \frac{(W_3 - W_1) \times 100}{(W_2 - W_1)}$$

Experiment # 5

Aim: To study cooking quality of rice.

Requirements: Test tubes, water bath, measuring cylinder, filter paper, Petri dish, test tube holder, strainer, rice sample

Theory: The quality of rice depends on its cooking characteristics whether they cook dry or wet and as gelatinized mass called as non-waxy or waxy rice and priced accordingly. The rice which cooks dry graded as good quality. Various tests to determine cooking quality of Rice are:

1. Optimum cooking time
2. Swelling index
3. Cooking coefficient
4. Residual solid loss
5. Water uptake ratio

Procedure:

1. **Optimum cooking time**

It is defined as the time at which starch gets properly gelatinized and grain is fully cooked.

a. 2g sample is taken in each of 6 test tubes and 20ml water is added in all test tubes.
b. The test tubes are kept in water bath.
c. Note the weight of rice after an interval of 5min after complete straining on filter paper.
d. A curve was plotted time v/s weight and the optimum cooking time was calculated from the curve. That time was taken where weight of sample rice becomes 2.5 times the raw one.

2**. Swelling index**

a. Take 2gms of rice and note down the volume by water displacement method.
b. Add 20ml water and cook for optimum cooking time.
c. Again take the volume of cooked rice by water displacement method
d. Calculate the swelling index as per formula

Formula:

$$\text{Swelling index} = V_1/V_2$$

Where,

V_1 =Volume of raw rice

V_2 =Volume of cooked rice

3**. Cooking coefficient**

a. Find out average length and width of raw rice by taking 10 grains.
b. Cook 2gms of rice by adding 20ml water for optimum cooking time.
c. Again, find out average length and width of cooked rice by taking 10 grains.
d. Calculate the cooking coefficient as per formula

Formula:

$$\text{Cooking coefficient: } (Lc - Lr)/(Bc - Br)$$

Where, c= cooked rice, r = raw rice

` Where,

Lc = Average length of cooked rice

Lr = Average length of raw rice

Bc = Average width of cooked rice
Br = Average width of raw rice

4**. Residual solid loss**

a. Cook 2gms of rice by adding 20ml water for optimum cooking time.
b. Drain the cooked water and collect in a cleaned, dried and pre weighed Petri plate.
c. Again take the weight of Petri plate along with drained water.\
d. Dry it in oven at 100°C.
e. After drying, take out Petri plate from oven and cool in desiccator.
f. Take the weight of Petri plate along with residual solid loss.
g. Calculate the residual solid loss as per formula

Formula:

$$\text{Residual solid loss (\%)} = \frac{\text{Weight of residue x 100}}{\text{Weight of sample}}$$

Residual solid loss relates with the quality of rice, less solid loss means good quality rice.

5. Water uptake ratio

It is defined as increase in weight of rice per gram of rice.

a. Cook 2gms of rice by adding 20ml of water for optimum cooking time.
b. Take the weight of cooked rice after complete draining of water on filter paper.
c. Calculate the water uptake ratio as per formula

Formula

$$\text{Water uptake ratio (\%)} = \frac{\text{Increase in weight of rice x 100}}{\text{Weight of sample}}$$

Experiment # 6

Aim: Study of wheat milling

Theory: Milling is defined as size reduction and separation operation used for food grains so that they can be converted into edible form by removing and separating inedible and undesirable portion from them. Wheat is of three types i.e. Hard, Medium and Soft.

Wheat Composition

Carbohydrate	70%
Protein	9-15%
Fat	2-2.2%
Fiber	2-2.5
Ash	1.8 %
Moisture	9-13%

Wheat Milling Process

Cleaning the wheat - The first milling steps involve equipment that separates grain from seeds and other grains, removes foreign materials that might have originated during the farmer's harvest such as metal, sticks, stones and straw and scours the kernels of wheat. It can take as many as six steps. The machines that clean the grain are collectively called the cleaning house.

1. Magnetic separator - The grain first passes by a magnet that removes iron and metal particles. It will pass through other metal detectors after milling to ensure that no metal pieces are in the finished product. Magnets are also positioned throughout the milling process and at the last step prior to load-out.

2. **Separator -** Vibrating or rotating drum separators remove bits of wood, straw and almost anything else too big or too small than desired grain.

3. Aspirator - Air currents act as a vacuum to remove dust and lighter impurities.

4. De-stoner - Using gravity, the machine separates the heavy material from the light to remove stones that may be the same size as the desired grain.

5. Disc separator/Cokle cylinder - The grain passes through a separator that identifies the size of the kernels even more closely. It rejects anything longer, shorter, more round, more angular or in any way a different shape.

6. Scourer - The scourer removes outer husks, dirt in the kernel crease and any smaller impurities with an intense scouring action. Currents of air pull all the loosened material away.

Impact Entoleter - Centrifugal force breaks apart any unsound kernels or insect eggs and aspiration rejects them from the mill flow. From the entoleter, the sound wheat flows to grinding bins, large hoppers that control the feeding of the wheat to the actual milling process.

Color Separator - Newer mills may also utilize electronic color separators to simplify the cleaning process.

Conditioning/Tempering wheat

Now the wheat is ready to be conditioned for milling. This is called tempering. Moisture is added in precise amounts to toughen the bran and mellow the inner endosperm. This makes the parts of the kernel separate more easily and cleanly. The length of soaking time can range from 6-24 hours. The time and temperature depend on the type of wheat and its moisture level. Temper water may be treated with ozone or chlorine to maintain sanitation in this wet environment during the tempering process.

Grinding (Milling) wheat

The wheat kernels are now ready to be milled into flour. Milling process is a gradual reduction of the wheat kernels to produce particles of endosperm which are then graded & separated from the bran by sieves & purifiers. Each size returns to corresponding rollers & the same process is repeated until the desired flour is obtained.

The millers' skill is analyzing the wheat and then blending it to meet the requirements of the end use. This science of analysis, blending, grinding, sifting and blending again results in consistent end products.

Wheat kernels are measured or fed from the bins to the "roller mills", corrugated cylinders made from chilled steel. The rolls are paired and rotate inward against each other, moving at different speeds. Passing through the corrugated "first break" rolls begins the separation of bran, endosperm (starch) and germ.

There are about five roller mills or breaks in the system. Again, the goal is to remove the endosperm from the bran and the germ. Each break roll must be set to get as much pure endosperm as possible. The "break" rolls, each have successively finer corrugations. After each trip through the break rolls, the grist is sent back upstairs to drop through sifters. The system reworks the coarse stocks from the sifters and reduces the wheat particles to granular "middlings" that are as free from bran as possible.

In some mills double high roller mills eliminate elevating and sifting the product between two successive passages in the milling process, thus increasing efficiency.

Sifters

The broken particles of wheat are elevated through pneumatic tubes and then dropped into huge, vibrating, box-like sifters where they are shaken through a series of bolting cloths or screens to separate the larger from the smaller particles.

Inside the sifter, there may be as many as 27 frames, each covered with either a nylon or stainless steel screen, with square openings that get smaller and smaller the farther down they go. Up to six different sizes of particles may come from a single sifter. Larger particles are shaken off from the top, or "scalped," leaving the finer flour to sift to the bottom.

The "scalped" fractions of endosperm called middlings are reduced in a smooth roller system to the particle size of flour. In hard wheat mills, the product is then subjected to a purifying process. A controlled flow of air lifts off bran particles while at the same time a bolting cloth separates and grades coarser fractions by size and quality.

The process is repeated over and over again, sifters to purifiers to reducing rolls, moving up and down and across the mill in a series until the maximum amount of flour is separated, about 75 percent of the wheat kernel.

Bleaching of flour

Toward the end of the line in the millstream, if the flour is to be "bleached," the finished flour flows through a device that releases a bleaching-maturing agent in measured amounts. This duplicates the natural oxidation that occurs when flour is allowed to naturally age as in the old days when flour was stored for a few months. This whitened the flour and improved its baking characteristics. The modern bleaching process simply duplicates this natural oxidation process, but does so more quickly.

In the bleaching process, flour is exposed to chlorine gas or benzoyl peroxide to whiten and brighten flour color. The bleaching agents react and do not leave harmful residues or destroy nutrients. In soft wheat products chlorine gas is also used to control cookie diameter and cake height.

Enrichment of flour

The flour stream passes through a device that measures out and releases specified quantities of enrichment. Malt may be added to bread flours at this point to add loaf height as well for flavor.

Grains have been enriched since 1941 with iron, riboflavin, niacin and thiamine. These nutrients help to prevent diseases pellagra and beriberi. In 1998, folic acid was added to the enrichment formula. Folic acid may help prevent heart disease, cancer, strokes and Alzheimer's disease.

Finished product testing

After milling, lab tests are run to ensure that the flour meets specifications. Millers also conduct routine monitoring of indicator natural organisms. Although dry flour does not provide an environment that is conducive to microbial growth. Flour is a minimally processed agricultural ingredient and is not a ready-to-eat product. Flour is not intended to be consumed raw. The heat processes of baking, frying, boiling and cooking are adequate to destroy any pathogens that may be present in flour and reduce the potential risk of food borne illness.

The North American Millers' Association is the trade association representing the wheat, corn, oat and rye milling industry. NAMA's 46 member companies operate 170 mills in 38 states and Canada. Their aggregate production of more than 175 million pounds per day is approximately 95 percent of the total industry capacity.

Experiment # 7

Aim: Study of Rice Milling

Theory: Milling is a crucial step in post-production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, and produce an edible, white rice kernel that is sufficiently milled and free of impurities. Depending on the requirements of the customer, the rice should have a minimum of broken kernels.

Milling systems

A rice milling system can be a simple one or two step process, or a multi stage process. In a one step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two step process, husk and bran are removed separately, and brown rice is produced as an intermediate product. In multistage milling, rice will undergo a number of different processing steps.

Rice is harvested from rice plant in form of seed called paddy, consisting of husk, bran, germ and starch. This starch part is called rice. Paddy is passed through several steps to get rice. These steps are husking, husk separating, paddy separating, polishing and grading. All these steps together are called milling.

Cleaning: Pre-cleaning is removal from the paddy of foreign material such as sand, stones, straw, metal particles, and other seeds - is the first step in modern rice milling. Cleaning not only produces clean rice but also protects the other milling machinery and increases milling capacity.

The impurities can be divided into large impurities, small impurities, and impurities of about the same size as the paddy grain. Large impurities normally consist of rice straw, panicles, bag string, soil, stones, and sometimes iron parts. Small impurities consist of dust, sand, soil particles, weed seeds, insects, and small stones. Impurities of about the same size as the paddy grains can be empty grains, stones, and iron particles.

In the pre-cleaning process use is made of differences in the size, weight, and sometimes length of the impurities compared to the paddy grain. Impurities lighter in weight than paddy can be removed by aspiration or by sieving. Large and small impurities heavier than paddy are removed by sieving whereas, particles the same size but heavier can be removed by gravity separation. Foreign material about the same weight and size as the paddy grain is difficult to remove, and it is presumed to disintegrate during the actual milling process.

Weed seeds are generally small impurities normally separated through sieves. If they are not separated during the pre-cleaning process, the seeds will not be processed during the milling operation and will finally be mixed with the end product, consequently down grading the white rice. In those rice mills that produce mainly white rice for high-quality markets, trieurs (rotating grading cylinders) are used to remove the seeds based on differences in their length as compared to paddy grains.

Iron parts or particles are removed by sieving, by gravity separation, or by permanent or electro-magnets.

Husking: Husk is a layer of cellulose protecting rice grain. Each paddy grain has 2 "half husk" interlocking each other, so it is easier to break the interlock and release 2 half husks from each paddy, this is the concept of Husking machine. Husking machine can be 2 stone or rubber surfaces moving at different speed or in different direction. Two surfaces are at a little distance apart, at paddy width which is normally 2-3 mm. As the surfaces move, paddy is fed into the space and the two half husk is rubbing off from each other and removed from paddy. Paddy is

not exactly the same for each grain, there may be some husk left intact with paddy. After this step paddy will turn to brown rice (husked paddy), husk and some intact paddy.

Husk separating: After husking, brown rice/husk/paddy passed through husk separating step, which is separating husk (lighter in density) from the rest (heaver density). This can be done by sieve or ventilation. When passing through large hole sieve, brown rice and paddy, which is heavier, will fall down the sieve leaving lighter husk floating on sieve. Separation also can be done by ventilation. Brown rice/husk/paddy mixture is drop through wind current. Wind will blow husk, which is lighter, away from the rest. After this step husk is separated from brown rice/paddy. Husk is burn for power or use as farm bed laying or for partition board.

Paddy separating: Brown rice/paddy mixture is feed into paddy separator. Generally this separation use the density factor, brown rice is a little denser than paddy. Normally brown rice/paddy mixture is softly shaken on an inclining metal sheet. With proper incline angle, paddy, which is lighter, will be separated from brown rice. Design of the metal is of individual technique. Separated paddy returns to husker for re husking.

Polishing: Brown rice is covered with bran layer which densely wrap around each grain. Polishing machine uses rubbing technique to remove bran layer from each grain. This rubbing can be either by rough stone surface or using sharp metal blade rubbing/cutting each rice grain. Rub out bran is removed by wind current, leaving milled rice. As polishing process is very rough, some grain will break, so rice miller usually pass brown rice through few polishing step. Each step lightly remove portion of bran layer so rice grain will not break. Some miller may use up to 5 passes of polishing, but 3 passes is the norm. Removed bran is collected and use for feed mill or cooking oil industry. Polish rice always contain broken rice, no matter how efficient the polisher.

Grading: Milled rice is passed through different type of sieve to take out broken rice. Sieve will separate broken from head rice (the nice whole grain) using the size difference property of head rice and broken. Broken, which is smaller will fall through sieve hole leaving head rice floating on sieve.