UNIT 5 FRUITS AND VEGETABLES

Structure

5.0 OBJECTIVES

After reading this unit, you should be able to:

- know production, composition, properties and factors responsible for determination of quality of fruits and vegetables and their control;
- describe post harvest handling, processing and storage of fruits and vegetables and by-product utilization of fruits and vegetables; and

- explain techno-economic feasibility of some small-scale fruits and vegetable base processing industry.

5.1 INTRODUCTION

Fruits and vegetables have an important place in our day-to-day life. Being rich in minerals and vitamins they are called protective foods. India's economy is based on the agriculture. India is one of the largest producers of fruits and vegetables in the World play a very significant role in the national economy.

India's geographical location and topography provides an excellent opportunity to produce every thing in our country. However, round the year availability of fruits and vegetables provides passive response towards commercial processing of fruits and vegetables. The people also have poor acceptability of processed foods. This often led to glut, more post harvest losses besides less contribution of processed foods in the national economy.

5.2 PRODUCTION AND IMPORTANCE

Fruits and Vegetables play an important role in agriculture, human health and national economy. In India, a decade back production of fruits and vegetables was just 50% of food grains production but it has been raised to 66% and anticipated that by 2010 it will be 80%. India is the second largest producer of fruits and vegetables in the world. India produces about 100,000 corers of rupees worth fruits and vegetables every year. However, a considerable amount of this produce in lost due to negligence and improper post harvest handling, which amounts to be 25 to 30%. Besides, this huge financial loss the wastage also affect the per capita availability of fruits and vegetables. It results in quality of health and life of majority of the people of the country.

You know, India with round the year sunshine, variate soil type, climate and topography produces variety of fruits and vegetable. Our nation is the largest producer (Table 5.1) of mango, banana, papaya, sapota, cashewnut, coconut, cauliflower, okra, capsicum, pea etc.

Though, our country is one of the highest producer of the fruits and vegetables but productivity is significantly lower in most of the fruits and vegetables as per the international bench mark (Table 1). The lower yields are mainly due to poor quality of planting material including varieties, unplanned farm management practices like fertilizer, water management and small from holding. However, some farmer have obtained better yield with competitive quality of international standard.

Table 5.1: Area, production, productivity of some fruits and vegetables

Fruits or vegetables	International benchmark (t / ha)	Area ('000 ha)	Production ('000 t)	Productivity (t / ha)	Percent world contribution (%)
Banana	35.5	491	16813	34.3	29 (I)
Mango	30.0	1487	10504	7.1	44 (I)
Papaya	-	60.5	1666.2	27.5	30 (I)
Citrus	24.5	527	4651	8.8	3
Guava	-	151	1711	11.3	- (IV)
Pineapple	60.0	76	1025	13.6	8 (III)
Sapota	-	64	800	12.4	- (I)
Coconut	-	1778	8429	4.7	18 (I)
Cashewnut	-	686	520	0.76	44 (I)
Cauliflower	-	248	4718	19.0	34 (I)
Pea	-	273	2712	9.9	38 (I)
Okra	-	349	3419	9.8	- (I)
Tomato	25.9	457	7427	16.3	9 (III)
Potato	-	1341	25000	18.6	8 (III)
Cabbage	-	258	5909	22.9	12 (II)
Brinjal	-	500	8117	16.2	38 (II)
Onion	-	493	4899	9.9	11 (II)

Source: NHB Data Book 2002

In spite of huge production, India shares only 2.3% of the world trade of fruits and vegetables. It also process only 2.5% of the total produce in a organized sector whereas Thailand 30%, Brazil 70%, Philippines 78% and Malaysia 80%. One of the reason is the varieties have poor recovery of process product for i.e. Indian tomatoes have 4 ^{o}b of total solids whereas varieties in European countries have 6 ^{o}b. Thus, to produce same quantity of tomato end product 50% more tomatoes are required in our country.

Fruits and vegetables processing industry ranks 5th in its size and employees 19% of work force which is about 1.6 million people. It accounts for 14% total industrial output against 5.5% industrial investment and contribute 18% to the GDP. Annual turnover of fruit and vegetable industry is Rs. 1800 billion and out of which Rs. 1400 billion are from unorganized sector.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name three fruits and three vegetables in whose production our nation ranks first in the world.

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2. Give two reasons for huge post-harvest losses of perishables.

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3. List the reasons for low farm yield as compared to the international benchmark.

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5.3 TYPE OF FRUITS AND VEGETABLES

The fruit is derived from the Latin word "fructose" which means to enjoy, produce. The fruit is a product of fertilization and is a ripened ovary. Fruits are classified into pome (apple and pear); stone (mango, peach, plum, cherry), berry (strawberry, tomato); nut (walnut, cashewnut); hesperidium (citrus); synconium (fig), sorosis (mulberry); coenocarp (jack fruit) and syncarp (custard apple).

The vegetables develop from variety of plant parts (cabbage pea, potato). On the basis of plant parts used as vegetables they are grouped as fruits (gourds, brinjal, capsicum); stem (asparagus, amaranths), leaves (cabbage, lettuce, spinach) flowers (broccoli, cauliflower) and underground portion (radish, carrot, potato, onion, garlic).

For processing or storage purpose fruits are also classified as climacteric and non-climacteric fruits. The climacteric fruits are those, which develop total senescence sometime after the harvest during storage. For e.g. apple, banana, ber, fig, guava, mango, pear, peach, papaya, sapota, tomato. Whereas non-climacteric fruits ripen on the plants. for i.e. citrus, grape, litchi, pineapple, pomegranate, strawberry etc. The climacteric fruits have high rate of

respiration and production of carbon dioxide and ethylene than the non-climacteric fruits during the process of ripening. It leads to change in colour, flvaour, texture and some chemical changes.

5.4 COMPOSITION AND FOOD VALUE

You know that fruits and vegetables are considered as protective foods as they are major source of nutritients such as vitamins and minerals. The quantity and quality of these nutrients vary with the variety, pre-harvest practices and maturity. These nutrients imparts their colour, flavour, and texture. Colour of the fruits is basically due to sugar derivatives of anthocynidins. Flavour in the fruits depends on the proportion of sugars and acids. Besides that there are some volatiles flavouring compounds. The texture of the fruits is governed by polysaccharides. Fruits are also containing phenolics compounds. They impart astringency, bitterness and aroma, which provide resistance to pathogens and stress.

Food value namely major constituent, vitamins and minerals of some important fruits and vegetables have been given in Table 5.2 A, B and C at their maturity stage.

5.5 PHYSIOLOGY OF FRUITS AND VEGETABLES

Physiological maturity is the state of harvest of fruits and vegetables, which provides some flexibility of time for marketing the produce, so that produce attain desirable eating quality when it reaches the consumer. The produce harvested prior to attainment of physiological maturity exhibit lack of flavour and loose moisture rapidly. If harvested late may be overripe and have very short post harvest life.

Objective and subjective methods for assessing the maturity of fruits and vegetables have been standardized. They are classified as :

- Physical methods
- Chemical methods
- Biochemical methods

Table 5.2a: Food values of fruits and vegetables

Name of produce	Major constituents (percent)					
	Moisture	Protein	Fat	Mineral matter	Fiber	Carbohydrate
Fruits						
Apple	85.9	0.9	0.1	0.3	-	13.4
Aonla	81.2	0.5	0.1	0.7	3.4	14.1
Banana	61.4	1.3	0.2	0.7	-	36.4
Guava	76.1	1.5	0.2	0.8	6.9	14.5
Lime	84.6	1.5	1.0	0.7	1.3	10.9
Mango	86.1	0.6	0.1	0.3	1.1	11.8
Orange	87.6	0.9	0.3	0.4	-	10.6

Papaya	89.6	0.5	0.1	0.4	-	9.5
Pear	86.9	0.2	0.1	0.3	1.0	11.5
Pineapple	86.5	0.6	0.1	0.5	0.3	12.0
Tomato	94.5	1.0	0.1	0.5	-	3.9
Leafy vegetables						
Cabbage	90.2	1.8	0.1	0.6	1.0	6.3
Drum stick	75.0	6.7	1.7	2.3	0.9	13.4
Radish leaf	87.4	2.2	0.5	2.6	2.2	5.1
Spinach	91.7	1.9	0.9	1.5	-	4.0
Roots and Tubers						
Carrot	86.0	0.9	0.2	1.1	1.2	10.7
Onion	86.8	1.2	0.1	0.4	-	11.6
Potato	74.7	1.6	0.1	0.6	-	22.9
Radish	94.4	0.7	0.1	0.6	-	4.2
Sweet Potato	68.5	0.7	0.2	1.0	-	38.7
Yam	78.7	1.2	0.1	0.8	0.8	18.4
Other Vegetable						
Brinjal	91.5	1.3	0.3	0.5	-	6.4
Ash gourd	96.0	0.4	0.1	0.3	-	3.2
Cauliflower	89.4	3.5	0.4	1.4	-	5.3
French been	91.4	1.7	0.1	0.5	1.8	4.5
Cucumber	96.4	0.4	0.1	0.3	-	2.8
Lady Finger	88.0	2.2	0.2	0.7	1.2	7.7
Pea	72.1	7.2	0.1	0.8	-	19.8
Pumpkin	92.6	1.4	0.1	0.6	-	5.3
Snake gourd	94.1	0.5	0.3	0.7	-	4.4

Source: NIN, ICMR, Hyderabad, 1999

Table 5.2b: Food values of fruits and vegetables

Name of Produce	Minerals, (mg /100 g)								
	Cal-cium	Phos-phorus	Iron	Magne-sium	Sod-ium	Pota-ssium	Copper	Sul-phur	Chlo-rine
Fruits									
Apple	10	20	1700	7	28	75	0.13	7	1
Aonla	50	20	1200	-	5	225	0.18	-	-
Banana	10	50	400	34	36.6	88	0.40	7	8
Guava	10	40	1000	8	5.5	91	0.34	14	4

Lime	90	20	300	-	-	270	0.16	-	-
Mango	10	20	300	27	26	205	0.20	17	3
Orange	50	20	100	9	4.5	93	0.58	7	5
Papaya	10	10	400	11	6	69	0.20	13	11
Pear	10	10	700	-	-	-	-	-	-
Pine-apple	20	10	900	20	34.7	37	0.36	20	13
Tomato	10	20	100	12	12.9	146	0.14	11	6
Leafy Vegetables									
Cabbage	30	50	800						
Drum stick	44	70	7000						
Radish leaf	12	90	4800						
Spinach	60	90	5000						
Roots and Tuber									
Carrot	80	40	1500						
Onion	180	30	700						
Potato	10	50	700						
Radish	50	30	400						
Sweet Potato	30	40	900						
Yam	50	20	600						
Other Vegetable									
Brinjal	20	60	1300						
Ash gourd	30	20	500						
Cauli-flower	30	60	1300						
French been	50	30	1700						
Cucu-mber	10	30	1500						
Lady Finger	90	80	1500						
Pea	20	80	1500						
Pumpkin	10	30	700						
Snake gourd	50	20	1300						

Source: NIN, ICMR, Hyderabad, 1999

Table 5.2c: Food values of fruits and vegetables

Name of Fruit/ Vegetable	Calorific value (cal/100g)	Vitamin A (IU/100g)	Vitamin B (mg/100g)	Vitamin C (mg/100g)	Nicotinic acid (mg/100g)	Riboflavin (mg/100g)
			Vitamin			
Fruits						
Apple	56	-	0.03	2	0.2	0.03
Aonla	59	-	0.03	700	0.2	0.03
Banana	153	-	0.04	19	0.3	0.03
Guava	66	-	0.03	300	0.2	0.03
Lime	59	26	0.02	63	0.1	0.02
Mango	50	4800	0.04	24	0.3	0.05
Orange	49	350	0.05	68	0.3	0.06
Papaya	40	2020	0.04	46	0.2	0.05
Pear	47	14	0.02	-	0.2	0.03
Pineapple	50	60	0.03	63	0.2	0.04
Tomato	21	320	0.04	32	0.4	0.05
Leafy Vegetables						
Cabbage	33	2000	0.06	124	0.4	0.12
Drum stick	96	11300	0.06	220	0.8	0.12
Radish leaf	33	6700	0.05	65	0.5	0.12
Spinach	32	5500	0.05	48	0.5	0.11
Roots and Tubers						
Carrot	47	2000-4300	0.04	3	0.4	0.02
Onion	51	-	0.08	11	0.4	0.01
Potato	99	40	0.10	17	1.2	0.01
Radish	21	-	0.06	15	0.4	0.02
Sweet Potato	159	-	0.05	-	0.3	0.01
Yam	79	434	0.06	-	0.7	0.08
Other Vegetables						
Brinjal	34	5	0.05	23	0.8	0.06
Ash gourd	15	-	0.06	5	0.4	0.01
Cauliflower	39	38	0.10	66	0.9	0.08
French been	26	221	0.08	14	0.3	0.06
Cucumber	14	-	0.03	7	0.2	0.02
Lady Finger	41	58	0.06	16	0.6	0.06
Pea	109	139	0.25	9	0.8	0.01
Pumpkin	28	84	0.06	2	0.5	0.04
Snake gourd	22	160	0.04	-	0.3	0.04

Source: NIN, ICMR, Hyderabad, 1999

5.5.1 Physical Methods

In the physical method, the maturity of the fruit is judged by visual observations or by simple methods. They are size, shape, colour, weight, specific gravity, firmness, juice content, total soluble solids (TSS), and produce holding strength by the pedicle of the plant.

Usually size and weight of individual fruit depends on several factors so they can be considered only when such factors are known. For ex. Cultivar, planting material, nutritive available, soil type and climatic condition effect the size and weight of individual fruit. Some fruits develop colour, angularity and their specific gravity changes with the maturity. In general fruit and vegetable when they attain maturity do not develop enough force required to detach them from plant. Table 5.3 provides some indices of maturity of fruits and vegetables.

Colour charts are used for determing the maturity of some fruits, which changes the colour on maturity like stone fruits, tomatoes and banana. Colour charts or photographs can be provided to the worker engaged in harvesting to make the process effective.

Firmness is measured as degree of softness of the fruit and measured by the penetrometer. After choosing an appropriate plunger, hold the fruit against firm surface. Press the plunger with the uniform speed till it punctures the fruit peel.

In some fruits like grapes, citrus, mango, muskmelon etc sugar is the main soluble solids in the fruit juices. Thus, total soluble solids (TSS) measured by the hand refractrometer can considered as index for degree of maturity of these fruits. In juicy fruits like citrus, juice content can be an index of maturity.

5.5.2 Chemical Methods

The fruit maturity is judged by the chemical analysis of the constituents. They are titrable acidity, TSS/acid ratio, sugar/acid ratio, starch content, tannin content etc. In many fruits acidity decreases with the maturity. It can be determine by titrating fruit juice with 0.1 normal sodium hydroxide and phenolphthalein as an indicator.

Some fruits acidity alone cannot be taken as index of fruit maturity. However, a ratio of TSS to acid provides better judgment. We have already read that TSS can be measured by hand refractrometer.

Sugar either free or as derivative play an important role in imparting taste, flavour and texture to the fruits. It is considered as reliable index of maturity of fruits. As the fruit ripens, its starch is partly converted into sugar. Thus, measurement of starch by colorimetric method or by iodine reaction method can also provide an index of maturity.

Table 5.3: Maturity indices for fruits and vegetables

Fruits/Vegetable	Maturity Indices/Characteristics
Mango	Specific gravity 1.01-1.02, fullness of checks and roundness of shoulders
Banana	Angularity to round shape change of colour in some cultivars

Citrus	TSS:acid =12
Grapes	TSS: acid=20
Apple	TSS 12; Firmness 7kg
Peaches/Pears	Colour change from green to yellow, TSS=12
Plums/ber	Skin colour change
Custard apple	Turning of skin as creamy white between segments
Pomegranate	TSS = 16
Brinjal	Glossy skin and seeds are not hardened
Cabbage	Solid
Carrot	Size
Brocoli/cauliflower	Compact flower
Cucumber/Gourd	Tender, before hardening of seed coat
Lady finger	Non-fibrous, tips of pods pliable
Onion	40-50% tops fall
Peas	Shining green, filled
Capsicum	Green and shining
Chilli (hot)	Dark red colour
Potato	Foliage get dried
Tomato	For processing : Red For medium distance market : turning stage (pink) For distant market : breaker stage (green ripe)

Source: Research compilation from different papers and reports of PHTS (Post Harvest Technology Subject)

5.5.3 Biochemical Methods

Evolution rates of carbon dioxide and ethylene are considered as the most reliable methods to judge the maturity index of the fruits. In the climacteric fruits, carbon dioxide evolution increased during ripening stage. Ethylene is considered as ripening hormone and is also a good indicator for judging maturity, suitability of storage and other end uses. However, for non-climacteric fruits their suitability has not been established.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why fruits and vegetables are called protective foods?

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2. Name the instrument used to measure the firmness of fruits and vegetables.

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3. Name the instrument used to measure total soluble solids of fruit juices.

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5.6 CULTURAL PRACTICES

Soil type and climate do affect the quality of the end produce. But these are not in the hands of the growers. The cultural practices like soil-water management, canopy management, fruit thinning, doze and time of mineral application chemical sprays, pest management, affect the quality and quantity of horticultural produce not only at the time of harvest but also during storage. It is difficult to analyze the effect of each one of them individually. Affect of cultural practices on citrus fruit is shown in Table 5.4.

Table 5.4: Cultural practices affecting the quality of citrus fruit

Cultural Practices	Size	Weight	Maturity	Rind thickness	Soluble solids	Acidity	Juice content	Ascorbic acid	Colour yellow
Excess irrigation	+	+	+	-	-	-	+		
Girdling	+	+			+	-	+		
Mineral Nutrition									
Nitrogen	-	-	-	+	+	+	-	-	-
Phosphorus	-			-	-	-	-	+	-
Potash	+	+	-	+	-	+	-	+	-
Magnesium	+	+			+	-	+	+	
Zinc	+				+		-	+	
Chemical Sprays									
Oil emulsion					-				-
Lead arsenate	-		+	+	+	-		+	
2,4-D	+	+	-	-	-	+			-
GA	-	-	+	+	-	+	-	+	

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Blank space shows no information available

+ : indicates positive effect; increase, hasten, thick, hard, smooth or good flvaour

- : indicates negative effect; decreases, delays, thin, soft, rough and poor flavour

5.7 PRE-HARVEST TREATMENTS

It is well known that mineral content greatly affect the fruit quality at harvest and changes after harvest. Post harvest shelf-life is mainly dependent upon level of calcium in the fruit. Usually application of higher level of nitrogen, phosphorous and magnesium and lower level of potash and boron leads to calcium deficiency in fruits and reduces the post harvest shelf-life. Pre-harvest treatments of calcium delays ripening and senescence and improves the quality of produce. Low calcium content in tissues lead to physiological disorders such as : (i) bitter pit in apples ; (ii) cork spot in pears; (iii) end rot in tomatoes ; (iv) tip burn in lettuce and (v) hollow heart in potatoes.

Application of zinc and boron improves the mobility of calcium in the leaves and to the fruit. It increases firmness, soluble solids, organic acids, and ascorbic acid and reduces disorders. Chemicals used to extend the shelf life of fruits and vegetables are listed in Table 5.5.

Table 5.5: Chemicals and their schedule of pre-harvest application to enhance

Post Harvest Shelf-life of Horticultural Produce

Fruit/ Vegetable	Chemical & concentration	Time of application (Days before harvest)	Response
1. Apple	Boric acid (0.1-0.2%) silver-nitrate, 75 ppm	60 and 45 45	Improve calcium mobility Enhance shelflife
2. Mango	Calcium nitrate (1%) Or Calcium chloride (0.6%) Bavistin 0.1%		Enhances shelf-life Controls anthracnose and Stem end rot
3. Mango	Thiaphenate methyl 0.05% Gibberllic acid 10-15 ppm Phosphonomethylcin 5%	10	Post harvest losses Delayed ripening High TSS
4. Guava	Calcium 0.6%	20 and 10	Delayed ripening
5. Ber	Calcium compound 1.79/litre Ethereal, 750 ppm	10	Delayed fruit ripening Hasten maturity
6. Grape	Calcium nitrate 0.75%	10	Reduces weight loss & decay
7. Onion	Meleic hydrazide 2000-3000 ppm	15	Reduces sprouting during storage and reduces losses

Source: Research compilation from different papers and reports of PHTS (Post Harvest Technology Subject)

5.8 SAFE HARVESTING

Harvesting is an important unit operation in horticultural crop production. Though, it appears simple but it does require certain skills. Harvesting period is usually short. Improper harvesting may result in poor quality produce and also damage the plant. Therefore, the harvesting is further subdivided in following sections:

- Identification
- Clipping / Cutting / Picking
- Collection
- Do's and don'ts of Quality Harvest

5.8.1 Identification

Identification of properly mature fruits based on the parameters studied earlier i.e. size, shape, colour, acidity, TSS, firmness etc is the first most important task of the person engaged in harvesting.

5.8.2 Clipping / Cutting / Picking

Identified fruit which is separated from the plant is called clipping/cutting/picking. Improper harvest not only damages the produce but also causes injury to the plant. Manual method of harvesting includes holding the fruit, twisting it and pulling it. It damages the fruit as thumb impression

and due to the pressure some times it injures the fruit near the pedicle and also plant stem. On such fruits mould growth is observed after 48-72 h. So they are not suitable for long distance transport.

Clippers and knives provide smooth cut with the desired length of pedicle. Long pedicle is likely to damage neighbouring fruits during transport. It is preferred to have as small a pedicle as possible. Some times fruits are not accessible. Pricking poles attached with collecting bags can be used without climbing on the tree. Tripod ladders could also be used, which are stable and person can reach the fruits.

5.8.3 Collection

In general harvested fruits are dumped on the ground. Where these fruits come in contact with soil. Impact by which it is dropped on the ground and microbes present in the soil contaminates the fruits. Therefore, harvested fruits are to be collected in cloth bags, put on shoulder. These bags are to be carefully unloaded in the plastic crates kept under shade. Plastic crates may be expensive in the beginning but they are reusable. They help in reducing post harvest damage during transport and provide sufficient ventilation to remove field heat. They can also be stacked easily.

5.8.4 Do's and Don'ts of Quality Harvest

i) Harvest as per the market need and proper maturity stage of produce.

ii) Use proper tool to harvest, bag-to collect and crate during handling.

iii) Containers used should be clean, smooth, free from rough edges.

iv) Avoid hand touching of the fruits.

v) Train pickers for harvesting, handling the produce.

vi) Keep produce free from soil contamination.

vii) Keep produce in shade.

viii) Harvest early morning or late evening as these are low temperature at that time.

ix) Field sorting and packing is to be promoted.

x) Cure the roots and tubers before storing.

5.9 POST HARVEST TREATMENTS

On-farm post harvest treatments are basically into two:

1. Removal of field heat by cooling
2. Disinfections of the produce

5.9.1 Pre-cooling

Cooling of fresh produce means removal of the field heat. You remember that in article 2.8.4 it was mentioned "harvesting/picking should be done in the early morning or late evening during low temperature". It is well proven that if the fresh produce temperature is lowered by $10^{o}C$ in first hour, its shelf life is

doubled. You know fruits and vegetables are living. They respire if the temperature is more, their respiration rate increases. Thus, during handling it releases more heat and deteriorates the quality of the produce. The fresh produce can be cooled by:

- Natural cooling
- Forced air cooling
- Hydro cooling

Natural Cooling

The natural cooling is the simplest method in which harvested produce is to be kept in shade on a pucca floor or polyethylene sheet. It is the slowest method of cooling and sometimes time taken to remove the field heat is so high that spoilage of produce starts during cooling itself. Some people misunderstood this and kept the freshly harvested produce in cold room. It may cause harm to the produce as warm fresh produce releases water which when condenses and spoils the produce. Thus, such places should be equipped with good ventilation to remove the field heat.

Forced Air Cooling

Cold air is blown above the freshly harvested produce. It is many times faster than the natural cooling. It suits most of the fruits, which cannot be dipped inside the water for hydrocooling for i.e. strawberry, grapes etc. The main advantage of forced air cooling is that it not only carried heat librated but also carries the moisture evaporated from the fruits. The only disadvantage is if excess air is blown. Then loss of weight of fruit is high.

Hydro Cooling

It is the most effective method in which freshly harvested produced are dipped in cold water or cold water is sprayed over them. The advantage of this method is that it is fastest method of cooling and washing the produce. However, it requires more energy because surface water of the fruit is to be removed before packaging is done by forced aeration. The temperature of water should not cause cold injury or the shower pressure shouldn't damage the produce.

5.9.2 Disinfections of Produce

Fruit and Vegetables are exposed to nature, which is a vast ocean of microbial load. As long as they are on the plants, there resistance power is more. Once detached, the produce needs to be disinfected. The produce can be disinfected by treating with the hot water or chemicals (fungicides).

Hot Water Treatment

Most of the microorganisms and heat sensitive. Thus by dipping the produce for 1 to 5 minutes (depending on type of produce) in hot water (50-55^{o}C) checks the microbial load. In some of the produce time-temperature combination for disinfection is carried out this is given in Table 5.6. After the hot water treatment produce is kept in a cool room and gentle air is to be blown. It removes surface moisture and cools the produce.

The heat treatment temperature and time depends on the type of fruit/vegetables, and their microbial load. Care should be taken that it should not affect the quality of fruit.

Chemical and Fungicidal Treatments

Dipping in aqueous solution of some chemicals reduces the physiological loss in weight and microbial load and enhances the shelf-life of the fruit and provides uniform ripening. Some chemical treatments are given in Table 5.7.

Table 5.6: Hot water treatment to horticultural produce

Fruits/ Vegetables	Temperature (^oC)	Time controls (sec/min)
Mango	52 ^oC 5 min	Controls anthracnose
Mango	46^oC 65 min	Anthracnose and fruits fly
Citrus	50 ^oC 2 min	Enhances post harvest shelf-life
Capsicum	55 ^oC 12 ± 2 sec	Checks respiration, PLW and shriveling during storage. Enhances Post harvest shelf-life and capacity to with stand thermal stress.

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Table 5.7: Post harvest applications of chemicals / fungicide

Fruit	Chemical / fungicide and doze	Treatment	Effect
Mango CV. Banganapally	Wax, 6%	1 min	Reduces PLW
Mango	Ethylene 10-100 ppm Ethepon/ Etheral 500 ppm	21-25^oC for 12-48 h hot water	Uniform ripening and colour development
Mango	Calcium chloride solution less than 4%	Dipping	Delayed ripening
Banana	Waxol –12 Potassium permanganate	Dipping	Delayed ripening
Banana	Sulphur 0.1%	Pasting	Control crown fungi
Grape	Sulphur oxide fumes or 0.5% water spray	Fumigation	Reduces respiration, enhances shelf-life and control growth and spread of rot
Citrus	Waxing bavistin or GA_3-200 ppm or Cytokine 20 ppm	Dipping/spraying	Control spoilage, enhances shelf-life
Guava	GA 200 ppm	Sealed PLDE bags	Enhances shelf-life
Peaches	Potassium permanganate 1000 ppm	Paper soaked lined CFB	Enhances shelf-life
Apples	Calcium chloride 2-3%	Dipping	Helps in ripening
Cabbage	Alum 15% or lime powder at butt end	Treating	Controls Bacterial soft rot

Source: Research compilation from different papers and reports of PHT (Post Harvest Technology Subject)

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name the physiological disorder occur in the potato and apples and its cause.

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2. List the steps of safe harvesting of horticultural produce.

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3. Why pre-cooling is essential in the fruits and vegetables?

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5.10 POST HARVEST MANAGEMENT

In our country the most (above 97%) of the horticultural produce is consumed as fresh. The post harvest handling involves movement of the horti produce from field to the dining table. This may be in bulk or retail. The better quality, produce fetches better returns. Therefore, the quality of produce is to be maintained by keeping a close eye on the movement of the produce. The steps involves are:

- Sorting
- Cleaning

- Trimming/chopping
- Waxing
- Grading
- Packaging
- Labelling
- Storage
- Transportation

5.10.1 Sorting

It is an important unit operation, which is advised to be carryout at the field itself. Removal of damaged, diseased, immature or over mature produce are to be rejected in the field. By removing them, the cost incurred in their transportation and handling can be saved. Moreover, these produce have higher respiration rate, so heat evolved by them is higher and very likely spoil the adjoining produce.

5.10.2 Cleaning

Fruits and Vegetables are exposed to the outer atmosphere. Thus, soil, dust and other impurities are adhered to their peel. Cleaning may be dry or wet (washing) is required to remove the adhered impurities from the produce. It helps in improving the appearance and also cools the produce. Some fruits, whose peel is very soft do not require washing with water like strawberry, kiwifruit, avocados etc. For them gentle air is blown to clean them. Fruits whose natural wax is removed during washing is also not washed with the water.

Spray washing or dipping in a tank with gentle brushing is done to remove adhered impurities. The choice of brushing mainly depends upon type of commodity and contamination.

Hygienic and sanitary conditions are to be maintained to check the spreading of disease and microbial load of washing water. Water may be treated with chlorine (100-150 ppm) to control spores.

5.10.3 Trimming

Some crops contain non-edible parts/excess leaves with the produce. These unwanted portion not only creat an unnecessary bulk but also lead to microbial infection and water loss. Thus such produce are to be trimmed/detopped before storage and handling.

5.10.4 Waxing

Food grade waxing of green vegetable like cucumber, tomatoes and fruits like citrus, apples, peaches is a common practice. It helps in reduction in loss of water during handling and marketing and enhances the shelf-life. Wax coating is done by mist applicator on a moving belt. After wax coating the produce their surface has to be dried before further handling.

5.10.5 Grading

Grading of the produce based on size or colour often fetches premium price in the market. Uniformly graded material provide better appearance and they are easy to pack. Experienced person generally does the grading in India manually.

However, for round produce, size base grades and for some specific fruits weight base mechanical graders are available in different capacity.

5.10.6 Packaging

The main purpose of packaging is to protect the produce during handling, transportation and storage from deterioration due physical, chemical or biological factors. Horticultural produce are highly perishables. After grading, the produce have the uniform maturity and requirement for safely against mechanical injury, and physiological activities like respiration. The package should have the following features:

- ✓ It should have sufficient mechanical strength which can withstand dead load during transportation (including impact and vibrations).
- ✓ It should be well aerated to remove respiration heat and humidity.
- ✓ It should be attractive and economical.

In general horticultural produce are handled through wooden cartons, corrugated fiberboard boxes and plastic crates. To avoid damage produce by touching each other liners/fillers are used of corrugated fiberboard or newspapers or grasses. Polyethylene lines are used to increase the humidity and decrease the water loss from the fruits.

5.10.7 Labelling

Fruits and Vegetables are delicate. Labelling of packages helps the people handling them during loading/unloading, stacking during storage or transportation. The label should contain information regarding maximum stack height, storage temperature and relative humidity conditions, date of packing and best before use. It should also have name of the commodity, its net weight and address of the producer.

5.10.8 Storage

In general fruits and vegetables are stored at low temperature and high humidity. It helps in reduction in respiratory rate and enhances the shelf-life. Appropriate storage conditions for storage of different horticultural produce is given in Table 5.8.

For temporary/transit storage for 1-day produce can be kept in the evaporating cool chamber where humidity is 90-95% and temperature is 10-15 ^{o}C lower than the atmospheric temperature.

Horticultural produce can be stored in modified atmosphere package (MAP) or controlled atmosphere (CA). In this storage, the oxygen concentration is reduced (in general below 5%) and carbon dioxide concentration is increased (3 to 7%). It helps in enhancing the shelf life and maintaining the quality for longer period.

Table 5.8: Storage conditions for fruits and vegetables

Produce	Temperature (^{o}C)	Relative Humidity (%)	Storage life
Fruits			
Apples	1-2	90-95	12 months
Grapes	1-2	90-95	1 month
Citrus	3-8	80-90	3 month
Peaches	1-5	80-90	2 weeks
Pears	1-5	90-95	4-6 weeks
Strawberry	2-5	95 +	1 week
Banana	12-15	80-85	2 week
Mango	10-15	85-90	3 week
Vegetables			
Cabbage	0-2	95-98	3-6 months
Cauliflower	0-2	90-95	4-6 weeks
Cucumber	10-13	95	2 weeks
Brinjal	10-12	90-95	1 week
Onion / garlic	0 to 5 or 25-28	65-70	6 months
Ginger	10-13	65	6 months
Okra	7-10	90-95	10 days
Pea (Green)	0	95 +	2 weeks
Potatoes	4-8	90-95	10 months
Tomatoes	12-15	90-95	1-2 weeks

Source: Food Preservations by modified atmosphere, By Calderon amnd Golan, CRC Press

5.10.9 Transportation

The refrigerated vans are the best method for transporting the produce from one place to another. However, it is not common practice in our country. Therefore, open vans with system of air movement to remove the respiratory heat should be practiced. In the van stacks should be arranged uniformly with thick cushioning pads (straw) to absorb the shocks.

5.11 PROCESSING OF FRUITS AND VEGETABLES

Fresh fruits and vegetables contain 70% or above water on wet basis. Large amount of water and respiration trigger the chain reactions of microbial activity. The purpose of processing is to develop value added products which are stable. The stability can be obtained by:

- ❖ Reducing the chemical potential of water by
  - ▪ application of heat → Pasteurization; Canning; Dehydration (Drying & reducing a_w); Concentration
  - ▪ addition of solute → Jams, jellies, marmalades; Salting
- ❖ Fermentation → Pickling; Beverages (Fermented & non fermented)

5.11.1 Reducing the Chemical Potential of Water

Water present in the fresh produce can be removed by dehydration or addition of solutes which can strongly bind the water and not allow it to take part in deteriorating reactions.

a) Dehydration

It is the simplest and the oldest method to remove the free water from the produce and make it shelf stable. The quality of dehydrated materials depends upon the method of drying, temperature and rate of drying. Natural sun drying is the oldest practice but it provides uneven drying, sometimes gets contaminates from the atmosphere. Therefore, indirect sun drying (solar dryer), or the dryers operated with electricity, diesel or gas can be used to develop good dehydrated product.

Prior to drying, the product is to be blanched and exposed to sulphur fumes which helps in drying and maintaining the colour and flavour of the dried product Table 9 provides the temperature required for drying different produce. Excess temperature may cause loss of nutrients and or caramalization of sugar. Dried product can be stored for few months without refrigeration.

Table 9: Drying air temperature and time required for drying for different produce

Produce	Drying air temperature (^oC)	Time required for drying (h)
Apple	50-55	6-8
Banana	50-55	6-8
Grapes	50-55	24-48
Mango (unripe)	50-55	24-36
Garlic	55-60	6-8
Onion (slices)	50-55	8-12
Pea	55-60	12-18
Green chilli (cut)	55-60	4-5
Spinach	55-60	4-5
Cauliflower	55-60	8
Potato chips	50-55	4.

b) Solute Addition

It is well known that by adding sugar or salt, fruits and vegetables can be preserved longer. These chemicals bind the water present in the food and thereby prevent the water to take part in deteriorating reactions. Jams, Jelly, fruit bar, preserves are sugar-preserved products whereas pickles are salt preserved.

The products can be made of intermediate moisture content (18-35%) by partially drying them in air. Such products retain more nutrients, colour, flavour and require less energy in product development.

5.11.2 Fermentation

It is an aerobic/partial anaerobic oxidation process. During the process desirable microorganisms are produced. Some of the useful products from fermentations are acids and alcohols.

The list of some products prepared from fruits and vegetables are given in Table 10.

Table 10: List of some products prepared from fruits and vegetables

Produce	Existing Products	Newer Products
Green Mango	Pickle, chutney, dried slices powder	Drink, juice, concentrate
Ripe Mango	Canned slices, pulp, juices nectar, jam, bar	Frozen slices, concentrate wine, vinegar
Banana (unripe)	Chips	Defatted chips and powder
Banana ripe	Pulp, figs	Powder, bar
Grapes	Raisins, juice, wine	Concentrate
Guava	Jelly, juice, nectar	Bar, powder
Apple	Juice, jam	Juice concentrate, bar dehydrated slices
Oranges	Juice	Juice concentrate, segments
Papaya (raw)	Tuttifruity	Papain
Papaya (ripe)	-	Pulp, slices
Aonla	Preserve, pickles, juices power	Salted and sweet segments
Pea	Dehydrated, brive solution canned	-
Carrot	Juice, pickle, canned	Dehydrated
Onion	Dehydrated slices powder	-
Tomato	Puree, sauce, drink	Powder
Chilli	Dehydrated, powder, pickle	Paste

5.12 BY PRODUCT UTILIZATION

Fruits and Vegetable processing industry is called as sunrise industry in the country. During the processing more than 50% of the material goes as waste. Thus, waste disposal and its utilization is a challenge.

The fruit industry waste contains mainly cellulose, starches, pectins, vitamins, minerals and other micronutrients. These waste can be used for oil, animal feed, fuel, manure and some value added products like pectins, tartaric acid, citric acid etc. Table 11 gives the different waste material and their possible value added products.

Table 11: By-products of horticultural produces and their possible uses

Produce	Waste	Possible uses
Mango	Peel, stone, kernel trimmings	Starch, fat, vineagar kernel flour, animal feed, manure, besides medicinal use to cure diarrhoea, piles etc.
Guava	Seed, core, pomace	Ethanol, oil from seeds, pectine, animal feed
Grapes	Stem, pomace, peel, seeds	Seed oil, cream of tartar, tannin, wine fertilizer
Citrus	Peel, seed, pomace	Molasses, peel oil, cosmetics, soap, textile, pectine, wines, citric acid

Check Your Progress Exercise 4

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why sorting at farm level is preferred?

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2. How sanitary conditions are maintained during washing?

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3. How waxing of fruits and vegetables enhances shelf life?

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4. List the properties of ideal fruit package.

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5. “Moisture is torture to fruits”. Explain?

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6. Why blanching is done prior to drying?

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5.13 TECHNO-ECONOMIC FEASIBILITY

Some product base techno-economic feasibility has been given. The plant capacity can be enhanced or some other products can be taken up with the same machines.

5.13.1 High Moisture Products like Fruit Jam, Jelly, Preserve, Canned Slices etc.

Plant capacity	100 kg/day
Land	20 × 25 m
Constructed area	12 × 15 m
Cost of machines	Rs. 5,00,000/-
Rolling capital	Rs. 75,000/-
Quality control klaboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Liquid waste water disposal system Electric power
Other utilities	Assured quality raw material Approachable Telephone
Rate of return	25% +
Break even point	45%

5.13.2 Intermediate Moisture Products like Raisin, Figs, Fruit Bar etc.

Plant capacity	100 kg/h
Land	20 × 25 m
Constructed area	10 × 15 m
Cost of machines	Rs. 6,00,000/-
Rolling capital	Rs. 1,20,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grader water Electric supply Liquid waste disposal system
Other utilities	Telephone Quality raw material Approachable
Rate of return	17% +
Break even point	About 60%

5.13.3 Dehydration Plant

Plant capacity	1000 kg/day
Land	20 × 25 m
Constructed area	15 × 15 m
Cost of machines	Rs. 10,00,000/-
Rolling capital	Rs. 2,00,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Electric supply Solid and liquid effluent disposal system
Other utilities	Telephone Quality raw material Approachable
Rate of return	21%
Break even point	62 % (about)

5.13.4 Tomato Processing (Juice, Sauce, Ketchup, Puree)

Plant capacity	1000 kg /day
Land	20 × 25 m
Constructed area	12 × 15 m
Cost of machines	Rs. 6,00,000/-
Rolling capital	Rs. 1,00,000/-
Quality control laboratory	Rs. 1,00,000/-
Essential utilities	Food grade water Quality raw material Effluent disposal system
Other utilities	Electric power, approachable , telephone
Rate of return	23 %
Break even point	65%

5.13.5 Fruit Juice, Concentrates and Beverages

Plant capacity	500 kg/day
Land	20 × 25 m
Constructed area	15 × 15 m
Cost of machines	Rs. 10,00,000/-
Rolling capital	Rs. 125,000/-
Quality control laboratory	Rs. 75,000/-
Essential utilities	Food grade water Effluent disposal systems Electric power
Other utilities	Approachable Assured quality raw material Telephone
Rate of return	35%
Break even point	50%

5.14 LET US SUM UP

Fruits and Vegetables are of immense significance to man. Their nutrition, taste helps in good health in a human being. In the present scenario where horticultural production has increased many folds in last few decades but due to poor post harvest management losses has also increased. It is estimated that losses in fruits and vegetables amounts to be Rs. 67,000 crores annually. The main places where losses or damage initiate in the horticultural produce are on the plant itself, harvesting time, handling and storage. These losses can be minimized by pre and post harvest treatments and post harvest management. Surplus produce can be diverted for the processing, which will also create employment.

5.15 KEY WORDS

Climacteric Fruits : Those fruits that develop total senescence sometime after the harvest during storage. Fruits having higher respiration rate, produces of carbon dioxide and ethylene more than the non-climacteric fruits.

Pentrometer : Instrument to measure firmness of produce

Refractometer : Instrument to measure total soluble solids in the produce

Sorting : Removal of damaged, diseased, immature or over mature produce.

Blanching : Heat treatment given to the produce prior to the drying to inactivate enzymes, stabilize product and facilitate easy drying.

Sulphiting : Soaking (30 minutes) in the solution of potassium meta bisulphite prior to drying to maintain the colour.

5.16 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Any three fruits: Banana, Mango, Papaya, Sapota
   Any three vegetables: Cauliflower, Pea, Okra

2. Reasons for huge post harvest losses are:

   i) Poor infrastructure facility at the production site.
   ii) Poor post harvest handling and transport facility.
   iii) Less awareness about safe harvesting, sorting and grading at farm level.

3. Reasons for poor farm yield compare to International benchmark are:

   i) Poor planting material
   ii) Unplanned farm management practices.

Check Your Progress Exercise 2

1. Fruits and vegetables are major source of nutrition (minerals and Vitamins) so they are called protective foods.

2. Penetrometer

3. Refractometer

Check Your Progress Exercise 3

1. In Apple – bitter pit
   In potato – hollow heart
   Due to low calcium content – in tissue

2. Steps of safe harvesting are:

   i) Use proper tool to harvest, bag-to collect and crate during handling
   ii) Containers used should be clean, smooth, free from rough edges
   iii) Avoid hand touching of the fruits
   iv) Keep produce free from soil contamination
   v) Keep harvested produce in shade

3. Fruits and vegetables respire and release the heat. The rate of respiration is high at higher temperature. It reduces the shelf life of the produce. So they are cooled.

Check Your Progress Exercise 4

1. Sorting at farm level helps in reducing the cost incurred in the transporting and handling of unwanted produce. Moreover, damaged and immature produce respire more and release more heat. Thus, it may spoil other adjoining produce.

2. Sanitary conditions can be maintained by treating with water containing 100 –150 ppm chlorine.

3. Waxing of perishables reduces the rate of respiration and checks water loss thus, it enhances the shelf life of the produce.

4. Ideal fruit package should have

   i) Sufficient mechanical strength to withstand dead load during transportation. (Including impact and vibrations)

   ii) Good aeration to remove respiration heat and humidity.

   iii) Be attractive and economical.

5. Moisture in the fruits triggers the chain reactions of microbial activities, so moisture is a torture.

6. Blanching helps in drying by evacuating the air from pore spaces, and stabilize the product from microbial load.

5.17 SOME USEFUL BOOKS

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