UNIT 9 PHYSIOLOGICAL DISORDERS

Structure

9.0 OBJECTIVES

After going through this unit, you should be able to:

- know the reason for different physiological disorders;
- mention the symptoms of major physiological disorders;
- state the importance of minerals in fruit quality; and
- tell how the occurrence of physiological disorders can be avoided.

9.1 INTRODUCTION

Physiological disorders are related to exposure of undesirable environmental condition such as temperature, very low oxygen or high carbon dioxide, humidity and nutritional disorders etc. In general any breakdown of tissues other than invasion of pathogens or mechanical damage is termed as physiological disorder.

Different fruits and vegetables have different tolerance limits to cold (low) temperature, storage below which the stored commodity is susceptible to various kinds of disorders including fungal infections.

9.2 PHYSIOLOGICAL DISORDER OF TROPICAL AND SUB-TROPICAL PRODUCE

Many tropical and sub-tropical varieties of fruits and vegetables when stored below 10°C for a longer time suffer physical and physiological injuries. These injuries are of the following types:

i) Superficial scald
ii) Carbon dioxide injury
iii) Core flush

iv) Breakdown of the flesh of the stored commodity:
   a) Low temperature breakdown [LTB]
   b) Senescent breakdown
v) Water core
vi) Bitter pit
vii) Freezing injury
viii) Chilling injury

1. Superficial scald

The common feature of this is that the areas of the skin of the stored commodity turn brown. These areas are very slightly sunken and the lenticels look as injured spots, e.g. apples, pears, and peaches.

2. Carbon dioxide injury

Usually occurs in CA storage when carbon dioxide concentration goes higher. The periphery of the internal tissue turns slightly brown initially and as the time of exposure to CO_2 prolongs the tissue turns deep brown, e.g. apples, pears, mangoes.

3. Core flush

Core flush is yellowish-pinkish discolouration of the core of the apples. It may appear as a ring of damaged tissue or it may involve the whole area of the core.

The incidence of the core flush is aggravated by increased CO2 concentrations in the core atmosphere. Storage in the absence of CO2 and in low concentration of oxygen gives good control of core flush.

4. Low temperature breakdown [LTB]

Low temperature breakdown of apple is seen in the cortical tissue as a general browning of the flesh that can vary in intensity from season to season.

As the disorder progresses the skin becomes discoloured and water logged, giving a dark translucent appearance. The cut surface looks moist.

5. Senescent breakdown

Senescent breakdown of apples and pears is a disorder associated with over maturity and it develops further at high temperatures when the fruit is removed from store. It is variable in appearance but fruit looks drier as compared to low temperature breakdown. Sometimes the flesh also becomes mealy.

6. Water core

Water core is a condition in which parts of the flesh of the commodity appear to be translucent and glossy because the intercellular spaces have become injected with the sap. It is more prominent in the flesh and may

also appear near to the surface of the skin. Water core disappears rapidly at higher storage temperatures, but badly affected fruits cannot recover from water core disorder.

7. Bitter pit

Bitter pit is appearance of small brown dry areas on the skin, which also disfigures the flesh. The location of the pit is usually below the skin, but in severe cases the pits may extend right up to the cortex. Under the microscope the pitted areas are seen to consist of dead collapsed cells. Deficiency of calcium in the soil causes bitter pits, and it can be avoided by pre-harvest spray of calcium. The bitter pit mainly occurs in pears, apples, and guavas.

8. Freezing injury

Freezing injury occurs when storage temperature falls below 0°C. The affected fruit externally has an irregular shape caused by tissue collapse, and the juice streams out of the injured or cut tissue even under slight pressure.

In apples, freezing injury characteristically occurs in cone-shaped segments with the apex at the core.

9.3 LOW TEMPERATURE DISORDER – CHILLING INJURY

Chilling injury is a major problem in post harvest handling of fruits and vegetables. This injury occurs at temperatures which are lower, but much above the freezing point of the tissues. Chilling injury is manifested in a variety of symptoms such as surface pitting, discolouration, appearance of water soaked areas, increased susceptibility to decay, loss of sprouting ability, etc. Some of the important physiological responses to chilling injury are stimulation of ethylene production, and failure of colour development.

Chilling injury is a phenomenon during which many tropical and subtropical fruits and vegetables when stored below 10°C develop the symptoms of skin discolouration and browning, pitting of the skin, water soaked spots, soggy flesh and failure to ripen when the commodity is removed to room temperature [RT].

The chilling injury symptoms are visible only after 2 or 3 days storage at room temperature.

9.3.1 Control of Chilling Injury

Temperature Pre-conditioning

Gradual reduction of storage temperature of the cold room is found beneficial in alleviation of CI. Pitting in stored banana was found reduced from 90.6 to 8.9% when stored at 13°C-12°C-11°C-10°C at 4 days intervals.

Regulating Humidity

Storage humidity at 95-100% was found to reduce CI symptoms in bananas stored at 11°C when they are covered in polythene bags.

Intermittent Warming

Intermittent warming [IW] of the commodity for every 5 days at low temperature/2 days at Room Temperature was found effective to control CI. Raw green mature papaya stored at 7°C for 5 days when transferred and kept for 2 days at RT did not exhibit CI symptoms for 3 weeks storage. Similarly, green mature bananas responded to this treatment with control of CI symptoms when removed to RT after 3 weeks I.W. at 8°C.

Wax Coatings

Suitable concentrations of wax coatings of the skin of papaya, banana and mango stored at 8°C for 2 weeks did not develop CI symptoms when removed to RT.

Modified Atmosphere Storage [MA Storage]

When the fresh commodity is enclosed in the thin low density polyethylene (LDPE) bags and stored at chilling temperature, the commodity stored, resisted CI up to 2 weeks. Banana, papaya and mango when enclosed in sealed polythene bags develop modified atmosphere and humidity inside the bag, which helps to alleviate CI symptoms. The fruits when removed to RT after 2 weeks of storage at chilling temperature and 8°C did not show CI symptoms.

9.3.2 Chilling Injury Symptoms

Fruit	Safe storage temperature (°C)	Symptoms
Banana	12	Brown streaking on screen
Cucumber	7	Dark coloured water soaked areas
Brinjal	7	Surface scald
Lemon	10	Pitting, red blotches, membrane staining
Mango	12	Dull skin, brown areas on skin
Papaya	7	Pitting, water soaked areas
Pineapple	10	Brown or black flesh
Tomato	12	Pitting

9.4 HIGH TEMPERATURE DISORDERS

Exposure to high temperature or direct sunlight can cause bleaching, scalding, uneven ripening and desiccation in horticultural produce. Sunburn scald in apple is an example of high temperature disorders and its symptoms vary from brown to black areas damaged by sunlight.

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. What is chilling injury?

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2. What are the symptoms of chilling injury in lemon and mango?

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3. What are the general symptoms of high temperature disorders?

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4. What is sunburn scald of apple?

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9.5 DISORDERS DUE TO ALTERED ATMOSPHERIC COMPOSITION

Although modification of atmosphere around produce is done to extend the shelf life of horticultural commodity, they are very sensitive with regards to the concentration of carbon-di-oxide and oxygen. High carbon-di-oxide levels cause uneven colour development and excessive softening in tomatoes. Reduced oxygen levels cause internal browning of pears. Some physiological disorders of fruits are shown in Table 9.1.

Table 9.1: Physiological disorders of fruits

Product	Disorder	Symptoms
Apple	Superficial scald	Sunken skin discolouration
	Sunburn scald	Brown to black area damaged by sunlight
	Senescent breakdown	Brown, mealy flesh
	Low temperature breakdown	Browning in cortex
	Water core	Translucent areas in flesh
	Brown heart	Brown areas in flesh
Pear	Core breakdown	Brown, mushy core
	Neck breakdown	Brown to black discolouration of vascular tissues connecting stem to core
	Superficial scald	Grey to brown skin speckles
	Brown heart	Brown areas in flesh
Grape	Storage scald	Brown skin discolouration
Citrus	Storage spot	Brown sunken spots on skin
	Cold scald	Superficial grey to brown patches
	Stem end browning	Browning of shrivelled area near stem end
Peach	Wooliness	Red to brown dry areas in flesh

9.6 MINERAL DEFICIENCY DISORDERS

Plants require a balanced mineral intake for proper development; if any of the essential minerals are deficient it will be manifested during plant development or in the plant or plant parts. Many times the browning symptoms in certain fruits and vegetables are attributed to the deficiency in some mineral constituents of the produce. These disorders can be prevented by either pre-harvest or post harvest application of specified minerals.

Calcium deficiency is one of the major problems. Calcium is physiologically important mineral as its deficiency may suppress respiration and several other metabolic sequences in plant tissues. Further, calcium is associated with pectic

substances in the plant cell that helps in strengthening of tissue. Potassium is other mineral that manifests its symptom both during excessive application and deficiency. Other minerals may also play role in maintaining proper plant and produce health. Toxicity of copper, iron and cobalt may cause similar symptoms to low temperature break down and superficial scald in apples. Copper also acts as a catalyst to browning enzymes (Table 9.2).

Table 9.2: Mineral deficiency disorders in fruits and vegetables

Fruit	Mineral	Disorder
Apple	Calcium	Bitter pit, cork spot, cracking, low temperature break down, senescent breakdown, water core
	Boron	Internal cork
	Potassium (High)	Bitter pit
Beans	Calcium	Hypocotyls necrosis
Cabbage	Calcium	Internal tipburn
Carrot	Calcium	Cavity spot, cracking
Mango	Calcium	Soft nose
Pear	Calcium	Cork spot
Pepper	Calcium	Blossom end rot
Potato	Calcium	Tipburn
Tomato	Calcium	Blossom end rot, cracking, black seed
	Potassium	Uneven ripening

Blotchy Ripening, Greenback or Solar Yellowing of Tomatoes

It is green, yellow or translucent hard patches of tissue spread over the red colour of ripe tomatoes. The parenchyma surrounding the vascular bundles of the outer fruit walls are necrotic and disorganized. The affected tissues may either be opaque or brownish in colour and are lignified and starchy.

The green areas of blotchy fruit contain less solids, nitrogenous compounds and sugars; more total and insoluble pectic substances; less pectinesterase and polygalacturonase activity; and lower titratable and total acids than the red parts.

Blotchy ripening of fruit may be affected by the nutrition of the plant. Potassium deficiency or excess nitrogen nutrition may bring about more blotchy fruits. Blotchy fruit may be not only a nutritional effect but also a result of stress leading to tissue compartmentalization. The blotchy section has different metabolic pattern than the normal tissue development.

Shading fruit with aluminium foil caused a decrease in the severity of greenback, whereas shading with black PVC foil increased its occurrence. Green back is caused by variations of temperature on the tomato fruit pericarp during maturation. The higher the temperature at any part of the fruit, the

greater the incidence of greenback. Temperature is a direct effect of incoming radiation and heat transfer coefficient. Factors such as variation in the chlorophyll content around the fruit, position of the fruit relative to the sun, stages of maturity, size and variety will produce localized temperature differentials. Metabolic activity would likewise differ, leading to blotchy ripening.

It is commonly observed that large fruits are more frequently and severely damaged by greenback than small fruits. The intensity of greenback depends on length of exposure and degree of temperature. Defective colouration of tomato shoulders is not primarily a heat effect but mainly a result of short-wave radiation. Short-wave radiation not only reduces the carotenoid synthesis in blotchy fruits, but also inhibits the C2H4 production.

Blossom-end Rot

This disorder is described as brown proteinaceous inclusions occurring in the epidermis and pericarp, at the stylar-end of the fruit. Cell membranes become disorganized and tissue necrosis develops underneath, the skin remaining intact. The causal factor for blossom end rot may be the Ca deficiency. This can be effectively reduced by application of Ca $(NO_3)_2$ and gypsum or by spraying with $CaCl_2$ solution. Excess K may also result in the production of blossom-end rot, probably through a Ca deficiency-induced effect. Water stress may aggravate this disorder.

Cuticle Cracks

Shallow, slightly dark, tiny but well healed cracks on tomato fruit surface are referred to as cuticle cracks or skin checks. Because the waxy covering is removed, water loss is rapid and shrivelling and discolouration follow. Cuticle crack is probably caused by the fluctuations in moisture regime and temperature.

Fruit Tumor or Waxy Blister

This disorder consists of a wax-like irregular tumor on the fruit surface starting as smooth, turgid blisters, which turn brown, depressed and cracked as the fruit ripens. Blisters may be induced by rubbing green fruits and storing at 20-35°C. The injury caused by rubbing apparently sparks the synthesis of more growth hormones with kinin like activity, which causes increased cell division and result in tumorous growth. Blister is mainly a handling disorder and may be controlled by careful picking, proper packing and minimizing damage during transport. Ripening at lower temperature is also recommended for avoiding this disorder.

Growth Cracks

This disorder is characterized by rupturing or cracking of the fruit, usually either around the stem-end (concentric) or from the stem-scar down the fruit shoulders (radial). Abundant rainfall and high temperatures favours rapid growth and predispose tomato fruits to growth cracks. The specific cause of rupturing could be an uncoordinated tissue expansion during growth or simply

a turgidity phenomenon. It may be controlled by picking before the fruits are ripe and by planting crack-resistant varieties.

Puffiness

Puffy tomato fruits are downgraded or are rendered unmarketable in serious cases. Affected fruit is hollow and light in weight. The surface between the internal cross walls is usually flattened or sunken. The large pockets are observed in cut tomatoes in the cavities occupied by the seed-bearing tissues.

Factors, which inhibit normal pollination, may cause poor development of seed-bearing tissues, and growth in such fruits lags behind the normally developing peel tissues leaving empty spaces between them. A too high or too low growing temperature, drought, excessive moisture supply and heavy N application interferes with normal pollination and hence should be avoided to reduce the incidence of puffy fruits.

Sunscald or Sunburn

Cabbage: Sunscald in cabbage starts as blistered, irregularly shaped areas that become papery and bleached later. Exposed leaves on the top of the head are usually affected. Because of possible secondary infection by decay-causing microorganisms, affected leaves should be removed prior to packing.

Pepper: The sunscald in pepper is due to exposure of the fruit to the intense heat of sunlight. Sunburn appears as light-coloured and soft areas on the fruit surface, which eventually becomes papery. Another type of injury, termed delayed sunscald, which appears after harvesting. Initially the fruit is water soaked and becomes dry and brown, but lacks the bleaching and papery symptoms.

Pomegranate: Exposure to the sun during fruit growth produces a brown, tough, leathery and slightly russetted patch on the rind.

Beans: Beans affected by sunscald appear first as tiny reddish spots forming reddish-brown streaks across the pods. At an advanced stage of sunscalding, pods become water-soaked followed by browning and shrinking of the affected tissue. This occurs only on one side of the pod, and is more serious during moist weather.

High Temperature – Induced Desiccation

Avocado (Heat Injury): Prolonged exposure of some cultivars of avocados to a temperature of 20°C causes damage to the fruit and the fruits held at 25°C to 30°C will not ripen normally. It causes uneven softening and discolouration may occur which makes fruit unpalatable due to off-flavours. The flesh darkens and brown spots appear on the skin. At 32°C, the flesh becomes rubbery and pitting like symptoms on the skin may occur.

Banana (Dehydration): Water loss in banana results in shrinkage of tissue or may even cause symptoms similar to severe chilling. Pitting in bananas may be induced either by high temperature or low RH. RH below 80% may produce symptoms characteristic of low-temperature breakdown. These effects lead to

abnormal ripening. Therefore to avoid dehydration, bananas should be promptly cooled after harvesting and stored at humidities between 90 and 95%.

Lychees (Browning): Lychee browning is a desiccation phenomenon due to exposure to dry air. It starts at tubercle tips, creeping downward and spreading on the bright-red shell. At an advanced stage, the entire surface of the fruit may turn completely brown. Browning may be reduced by storing at 2°C for up to 5 wk or at 7°C for less than 2 wk in polyethylene bags.

Onions (Translucent Scales): Translucent scale of onions consists of clearing of the normally opaque cells due to a disintegration of the parenchyma walls. It looks similar to freezing injury, however the distinguishing features are mentioned below:

	Freezing Injury	**Translucent Scale**
Pattern of damage	From the surface inward	No pattern
Stem plate	May be affected	Not affected
Scales	Outer more affected than inner	Inner may be more affected than outer
Freshly cut surface	Dry	Moist
Areas of white opaque tissues	Present	Lacking
Epidermis of affected scales	Loose	Loose only in severe cases
Texture of surface with epidermis removed	Grainy, rough	Smooth, slick

Major factors influencing the severity of this disorder include delays at 15 to 30 days between the end of curing and the start of storage at 0°C during 7 months storage. Tropical conditions where the temperatures goes above 32°C for about 50% of the growing period or above 35°C for about 30% of growth period of the plant, have high probability of developing this disorder during storage. Prompt cold storage and early covering the bulbs with soil reduces the incidence.

Growth Cracks and Splitting

Pomegranate (Splitting): Cracking of pomegranate during ripening is a natural characteristic believed to be due to humidity fluctuations, dry winds and irrigation. Picking over-mature fruit should be avoided to prevent cracking during storage. Cracked fruit may serve as an avenue for entrance of decay-causing organisms

Sweet potatoes (Growth cracks): Fairly deep fissures may develop on sweet potatoes due to successive growth interruptions in the field. In some cultivars, high N fertilization and irrigation followed by a dry weather may induce growth cracks.

Disorders Related to Certain Field Conditions

Carrots (Scab Spot complex): Early signs of scab spots of carrots are pockets of black necrotic tissues occurring usually at or near the lateral rootlets, which later become sunken and scab-like. The cause of this disorder could be related to nutritional, climatic and genetic factors.

Potatoes (Surface Browning): Under conditions of low RH and high harvest temperatures, some portions of mechanically injured tubers undergo oxidation, resulting in objectionable surface browning. The affected area darkens with time and becomes much more noticeable after a few days. Surface browning may be induced at RH ranging from 25 to 30%. Temperature is secondary to RH as a factor in browning, but higher temperatures are associated with low RH, thus compounding the predisposition of tubers to oxidation.

Mango (Black-tip): Orchards near the brick kiln suffer heavily every year due to black tip necrosis of mango. Small-etiolated area at distal-end of the fruit appears after 3 to 4 days of fruit setting. It gradually increases in size and the tip becomes necrotic, often exposing the stone of the fruit as a result of disintegration of outer tissues. Affected fruits do not mature properly and tip becomes hard and black.

Regular sprays of boron from the flowering stage can control this disorder. Spraying mango tree with aqueous solutions of NaOH and Na_2 CO_3 minimizes losses due to black-tip.

Pineapple (Endogenous brown spot or black heart): This physiological disorder in its early stages is characterized by the formation of watery spots at the base of fruit lets near the fruit core. With increase in severity of the disease, the spots enlarge and turn brown; with further increase in severity, the spots turn darker and may join together to form a dark mass in the centre of the fruit.

It can develop in the fruit if the pineapples are chilled at low temperatures. There are no visible symptoms of the disease in uncut fruit either before or after the onset of the spots in the pulp, thus making it impossible to remove affected, fresh fruit prior to shipment. Hence, losses in commercial surface shipments of refrigerated fruit have been high, but no losses occur in non-refrigerated air shipments.

Storage Disorders

Onions and other commodities (Ammonia injury) Accidental exposure of onions to ammonia during cold storage may bring about marked discolouration. Red onions change to blackish-green and then dull greenish-black later. Yellow onions show initial yellowish-green colour on the edges of scales, turning bronze to brownish-black at an advanced stage. White onions become greenish-yellow on exposure to ammonia. Discolouration is always much more rapid and pronounced in a more humid atmosphere. Exposure to a 1% ammonia vapour for one hour is sufficient to initiate discolouration. Exposure to higher concentration of ammonia from leaks in cold storage may bring about colour changes almost immediately, and brownish-black areas may be seen within a few minutes.

Other Fruits and Vegetables are also Injured by Exposure to Ammonia

Banana	-	brown to black and tissue breakdown;
Grapes	-	discolouration of berry and complete breakdown of the tissue;
Citrus (sweet orange and lime)	-	dark brown discolouration of the rind;
Mango	-	brown surface, pitting and breakdown of the tissue;
Potato	-	brown to dark brown pock marks, pitting, internal discolouration and watery breakdown
Tomato	-	impaired colour development, discolouration of the skin and breakdown of the tissue.

Potatoes (Greening): Greening of potatoes exposed to light during storage occurs due to synthesis of bitter, toxic alkaloid solanine. Although chlorophyll formation is independent of solanine synthesis the same factors, i.e., light quality and intensity, storage duration and age of tuber, affect solanine formation.

Sweet potatoes (Internal breakdown): Internal breakdown is a storage disorder where the internal tissues of sweet potatoes are pithy, dry and spongy. This usually occurs late in the storage season in warm and dry storage rooms, or in rooms with chilling temperatures.

CA Storage Disorders

Two types of disorder may be developed under a CA storage condition: injury due to sub oxidation and that due to CO_2 accumulation. Other volatiles may accumulate in the storage rooms above the critical level resulting in the development of off-flavours and off-odours and progressive death of the tissue.

Sub-oxidation causes blackheart in potatoes, promotes browning in limes, or produces off-flavour and objectionable alcoholic odour in many fruits and vegetables. High CO_2 on the other hand, (a) produces a slight carbonated taste in melons; (b) a general browning of surface (e.g. asparagus) and internal tissue (e.g. cabbage); (c) a stimulation of ethyl acetate production on strawberries (d) off-flavour; (e) off-odour; (f) pitting; (g) impaired ripening; (h) susceptibility to decay-causing microorganisms; and (i) mild necrosis in some fruits and vegetables.

Disorders of Uncertain Causes

Escarole (Marginal browning)

Edges of leaf blade become dry, dark, curly and brittle. The control measures include refrigerated transit, adequate refrigeration, prompt pre-cooling and marketing, removal of old leaves and discarding over-mature escarole may minimize the occurrence of marginal browning

Garlic (Waxy breakdown)

Garlic bulbs are seriously affected by a yellow waxy breakdown believed to be a physiological disorder. The flesh of the clove is somewhat sticky or waxy to the touch but not disintegrated. The outer scales show no indications of breakdown.

Lettuce (Marginal browning: Pink rib and russet spotting complex)

Marginal browning is a physiological disorder characterized by yellowing, followed by browning or necrosis of wrapper-leaf margins. Adverse growing conditions or improper transit and storage conditions, which accelerate senescence, appear to be the origin of this disease. Control measures include refrigerated transit, adequate refrigeration, prompt pre-cooling and marketing, removal of old leaves and discarding over-mature lettuce may minimize the occurrence of marginal browning.

Heads of lettuce affected by pink rib have pinkish, wrinkled and pebbly textured midribs. Over-mature lettuce or plants held long in storage show higher incidence of pink rib. The causative factor is not known. The control measure includes the measures adopted to delay senescence.

Russet spotting complex includes several types of discolouration originating from the field, transit and storage, but distinction among them is uncertain. These symptoms include russet, vein browning, C_2H_4 burn, red heart, internal browning, brown spot, brown blight, rust or storage breakdown. In general, the variable symptoms are irregularly shaped specks ranging in colour from light yellow, pink to dark brown, affecting the ribs, veins and interveinlet tissues. Because of the complexity of origin, only routine quality control measures may help to ameliorate the disorder. Thus, harvesting properly matured heads, rigid grading and culling at handling points, use of refrigerated trucks during transport and prompt pre-cooling and marketing may reduce its incidence.

Mango (Internal breakdown): This physiological disorder is most common in ‘Alphonso’ mango. It is termed as ‘internal breakdown’, ‘spongy tissue’, or ‘soft centre’. So far it is observed only in this cultivar. Externally, the fruit appears to be sound. The disorder is noticed when the fruit is cut into halves. It is observed only in semi-ripe and ripe fruits. The breakdown tissue is characterized by pale yellow colour, soft or spongy texture with or without off-flavour. It starts from the tissue adhering to the stone and gradually spreads to the periphery. In extreme cases, the whole flesh portion becomes too soft resembling bacterial rot. The causative factors for the onset of this breakdown and its control are not known.

Pomegranate (Internal breakdown): Internal Breakdown of pomegranate is characterized by arils, which become light in colour; flat in taste; and sticky in appearance. White lines radiate in all directions from the seed to the outer wall or aril.

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. How high carbon dioxide and low oxygen are detrimental to fruits and vegetables?

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2. Explain the importance of minerals in quality of horticultural produce?

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3. Explain the role of calcium in avoiding certain physiological disorders.

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4. How copper is helpful in maintaining quality of produce?

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9.7 LET US SUM UP

Different advance techniques are used during production as well as storage of products. It is important to use these techniques properly so that spoilage of product due to physiological disorders can be avoided. Preventing the metabolic sequences that leads to the development of disorder can prevent disorders. Sometimes chemicals are used to prevent the disorders. Genetic improvement of horticultural cultivars may also help in alleviating the occurrence of disorder. Physical methods of maintaining optimum storage temperature and storage atmosphere may help in reducing many disorders.

9.8 KEY WORDS

Disorders : Not a normal growth or product.

Symptoms : The condition that accompanies something and indicates its existence.

Nutritional : Substances that promote growth.

Ethylene : A colourless flammable gas which stimulates ripening.

Browning : To become dark or surface develops brown pigments.

Deficiency : Absence of some essential thing forms the nutrition.

Toxicity : Consumption of which acts as a poison.

Genetic improvement : Improvement of quality of a product by using the improved hereditary material.

9.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answers should include following points:

   - Low temperature storage
   - Surface pitting
   - Ethylene production
   - Uneven ripening

2. Your answers should include following points:

   - Pitting
   - Dull skin
   - Skin discolouration

3. Your answers should include following points:

    - Bleaching
    - Scalding
    - Desiccation

4. Your answers should include following points:

    - High temperature disorder
    - Sun scorching

Check Your Progress Exercise 2

1. Your answers should include following points:

    - Softening
    - Improper colour development

2. Your answers should include following points:

    - Proper development
    - Deficiency manifested in form of disorders

3. Your answers should include following points:

    - Pectic substances
    - Deficiency suppresses respiration

4. Your answers should include following points

    - Catalyst
    - Deficiency causes disorder

9.10 SOME USEFUL BOOKS

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