Fruit and Vegetable Processing

Level-II

Based on June 2021, Version 3 Occupational standards (OS)



Module Title: Performing Fresh Produce Grading Equipment

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Introduction to the module

This module covers the knowledge, skills and attitude required to program grading equipment to identify key characteristics of fresh produce and sort accordingly. This module contains detail on confirm produce grading specification and program grading equipment**.**

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LG #1	LO #1 Confirm produce grading specifications

Instruction Sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Describing grading equipment and process.
- Examining characteristics of produce and confirming purpose for grading.
- Confirming Customer and packaging requirements.
- Determining Specifications for grading

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Describe grading equipment and process.
- Examine characteristics of produce and confirming purpose for grading.
- Confirm customer and packaging requirements.
- Determine specifications for grading

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information sheets
4. Accomplish the self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information sheet 1

1.1 Describing features of the grading equipment and process

1.1.1 Features of the grading equipment and process for fruit and vegetable

Automatic fruit vegetable grading machine, adopting balance and lever principle, is utilized to classify fruits and vegetables by weight. Fruit sorter machine is characterized by accurate weighing precision, adjustable sorting grade and etc., and it is widely used for sorting apples, pears, persimmons, and other round fruits. Features of Automatic Fruit Sorting Machine:

- Advanced design, steel structure with long service life, convenient to move and easy to maintain.
- Fruit sorter machine is automatic, saving labor and time, and controlled by PLC, easy to operate.
- The sorting grade can be adjusted based on your demands.
- High output, low power consumption and low noise.
- Durable and well design fruit plate, no damage to the fruit.
- In the automatic transmission, fast accurate measurement and correct classification for various grades of fruits and vegetables.



Figure 1.1: Automatic vegetable & fruit grading machine
(https://www.youtube.com/watch?v=qhlEgmVG5Cg , Accessed: Date Nov 30, 2023)

Roller Grader: The rolling bar fruit and vegetable sorting machine is composed of a frame, the rolling bars, a conveyor chain, a transmission and other parts. After washing, the fruits are put or conveyed on

the roller bar, and move forward on the roller bar while rotating 360° under the drive of the roller bar. In this way, the operators on both sides of the machine can clearly observe the condition of the fruits, and pick out the unqualified fruits, and place them in the waste fruit collection device or in the waste fruit collection conveyor for further processing.



Figure 1.2: Fruits vegetables grading sorting machine with rolling bars for date's fruit

This type of graders is fast, precise and reasons little damage to fruit. These are widely used in the fruit industry. Each roller rotates in a counter clockwise direction. The fruit is continuously rotated so that each piece has a chance to record its lowest dimension with the space in the grader. Roller conveyers with fixed space among the rolls are used for eliminating small fruit, twigs and leaves



Figure 1.3: Potato and carrot roller grader

Orange grading machine: Whatever the size or shape of your oranges, grading machine handles them all. Its unique rotating carrier creates a 360° view of each orange, allowing you to analyze the entire surface for quality characteristics and defects such as blemish, calyx, rot, stalk, crease, corrugations, mold, oleicellosis, end checks, navel deformations and more.

Orange grading machine volumetrically weighs every orange at high-speed using images from advanced cameras. The unique software also monitors the average product weight and capacity per hour.

Every orange rotates under the camera as 40 images are taken to measure the entire surface. This lets the machine calculate the precise diameter, length and surface area. It will also recognize shape related defects or doubles (2 oranges in 1 cup).

Ultrafine color separations are created using software allowing operators to quickly create or modify color profiles. Then using live feedback from the cameras, the orange color is accurately graded.



Figure 1.4: Orange grading machine

The grading is completed based on the weight of product. This technique is precise, fast and there is least damage to fruits. This is also used for large size products like oranges, apples, potato, mango, eggs, tomato etc. These are especially adapted for sorting material, which cannot be handled by other procedures, due to their shape or texture. The material to be graded is positioned in individual cups by automatic feed, which is then passed through the sorter, where it is indexed with the help of spring- loaded trips. The spring tension is gradually weakened from the start to the end of the movement. Initially a large portion is the discharge whereas the lighter fraction is the next and the lighter at the end. This kind of grading does not depend on their size and shape of the material.

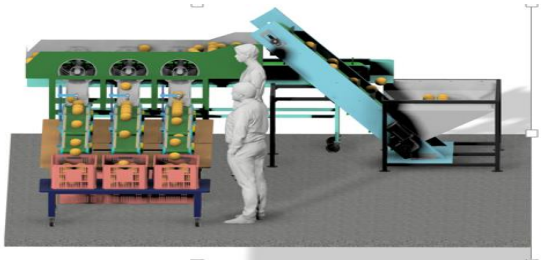


Figure 1.5: Mango apple weight grader

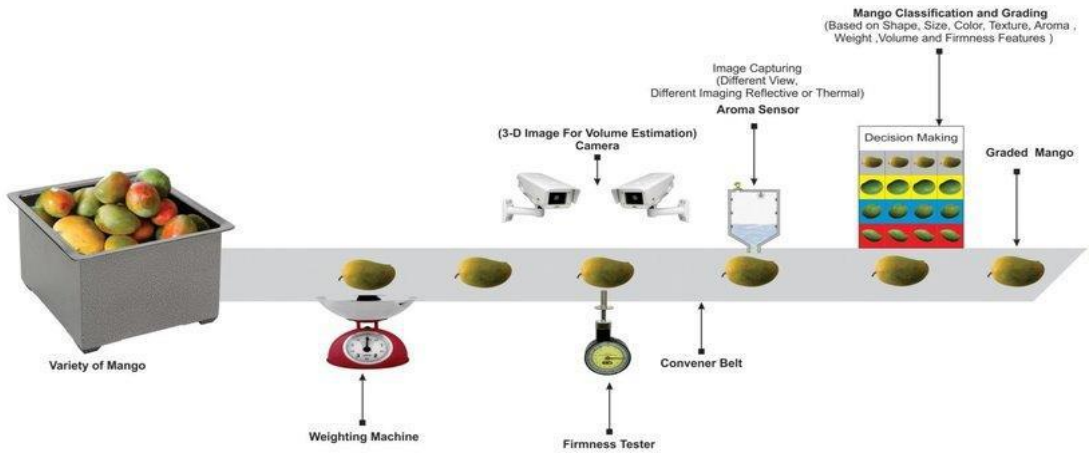


Figure 1.6: Fruit sorting and grading system

Drum type fruit and vegetable grading machine: Drum Type Fruit And Vegetable Grading Machine: Fruits and vegetables grading machine is suitable for round or similar fruits and vegetables grading, can be divided into small, medium, large, large four levels, grading aperture can be customized according to user requirements. The inside and outside of the roller and the outlet are all polished to eliminate fruit and vegetable damage as much as possible. The tilt angle of the roller can be adjusted, this equipment replaces the manual selection and grading, greatly reducing the work and labor. Drum Type Fruit and Vegetable Grading Machine Features：

- Suitable for round or oval shaped products to be graded according to different size, such as date, tomato, potato, garlic, carrot, mushroom, oyster, seafood, etc.
- Customized sorting size range and grades according to requirement.
- Polished drum including discharge port, inside and outside surface, eliminate the damage of fruits and vegetables as much as possible.
- The inclination angle of the drum can be adjusted.
- Equipped with a speed regulating motor and anti-collision pad, the speed can be adjusted according to the variety to reduce the impact force and ensure that the product is not damaged.
- Replace manual selection and sorting, labor saving with high performance.

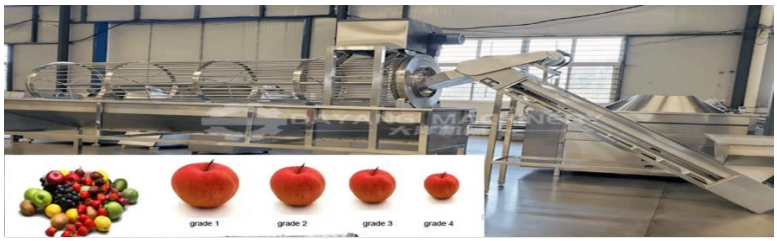


Figure 1.7: Drum type fruit and vegetable grading machine

Grading is the assessment of a number of attributes to obtain an indication of overall quality of a fruits and vegetables. This term is often used interchangeably with sorting but strictly means „the assessment of overall quality of a fruits and vegetables using a number of attributes". Sorting (that is separation on the basis of one characteristic) may therefore be used as part of a grading operation but not vice versa.

Grading: Selected fruit and vegetable are graded according to size and colour to obtain uniform quality. This is done by hand or machines such as screw grader and roller grader. Grading is carried out by operators who are trained to simultaneously assess a number of variables. Apples are graded with the assistance of coloured cards that show the required characteristics of different grades in terms of colour distribution across the fruit, surface blemishes and size and shape of the fruit. In some cases the grade of fruits and vegetables is determined from the results of laboratory analyses. In general, grading is more expensive than sorting owing to the higher costs of skilled operators. However, many attributes that cannot be examined automatically can be simultaneously assessed, and this produces a more uniform high- quality product.

Grading is completed by means of accurate equipment for each product of the product category. Most of the mechanical graders depend on the size of the materials, but some devices use differences in the shape, density and surface properties of the products to be sorted.

It is mainly due to availability of abundance of labour and lack of organized large-scale fruit or vegetable farming. However the nation's cereal requirements are now being met through systematic approach and importance of fruit and vegetables production is in the process. Now the trend is emerging towards the organized fruit and vegetable farming. As this trend will continue, there is a need to develop simple mechanical devices for harvesting fruit and vegetable. In traditional method of harvesting tall tree fruits such as mangoes, palm, coconut etc many serious accidents happen every year. By developing simple mechanical harvesting devices may avoid such accidents or reduce it.

A lot of efforts have been made towards the fruit and vegetable harvesting, abroad. Harvest mechanization has reached a high level of success and acceptance for number of crops. Successful mechanization of these operations requires a systems approach and need the joint efforts of engineers, plant physiologists, food scientists and others. Mechanical harvesting often causes a reduction in harvested crop value per unit area mainly due to

- Crop do not mature uniformly,
- Fruit and vegetable damage,
- Actual field losses, and
- Reduction in quality

1.1.2 Grading machinery

Mechanical fruit graders are categorized by their working principles as weight grader, fruit color grader and fruit color, size grader and weight grader which categorizes fruit by their color and size. Grading will be completed manually or by automatic grading lines. Sizing grading is subjective (visually) with the usage of standard size gauges. Round product elements can be simply graded with sizing rings. Grading basically divides the material into different homogeneous groups according to its exact features based on shape, size, color and quality. This saves the time and energy on different processing performances. Grading has altered very slightly in the period of last fifty years. Although the grading procedure is purely mechanical A basic mechanical grader consists of a chain conveyor belt and a bag at the end. Smaller products fell through the chain, simplifying the grading method.



Figure 1.8: Fruit and vegetable grading machine (https://www.youtube.com/watch?v=-9TnBIJIX-U , Accessed date, Nov 30, 2023)

Four types of grading machines for fruits are:

- Roller Grader
- Screens Grader

- Weight Grader
- Diving Belt Grader

Rotary drum fruit vegetable sorting machine: Rotary drum root vegetable grading machine is applied to sort round or oval shape fruits and vegetables according to the size of screen mesh.

a) The inside and outside of the rotary drum, the outlet, and other parts are polished, which reduces damage on fruits and vegetables.

a. The sorting machine is made of stainless steel in order to wash it conveniently after finishing the working.
b. It finishes all the processes from transporting to sorting automatically, which increases efficiency and saves labors a lot.
c. The angle of rotary drum inclination can be adjusted, and the screen diameter of the hole can also be customized based on customers' demands.
d. Equipped with adjustable-speed motor and collision chock.
e. Able to adjust the rotary speed to reduce the collision depending on the property of fruits/vegetables.
f. Take advantage of the screen mesh size to sort fruits and vegetables, suitable for sorting round or oval shape fruits and vegetables, such as nuts, mushrooms, water chestnuts, grapes, and other round materials.

Rotary drum grader machine is made of stainless steel, and the sieving screen is punched and then processed, in order to protect fruits/vegetables from damage during the sorting. The screen diameter of the hole can be customized based on customers' demands. Fruits or vegetables after cleaning are transported into the grader machine by the elevator. Under the function of the transmission equipment, the rotary drum keeps running, thus fruits/vegetables will be classified.



Figure 1.9: Rotary drum fruit vegetable sorting machine

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- Roller Grader
- Screens Grader
- Weight Grader
- Diving Belt Grader

Screens machines grader: There is variety of fruits which are graded with the help of vibrating screens made up of plastic, stainless steel and copper, which do not respond chemically with the products. The material to be graded is passed over to the rotary screen or vibrating screen. At the end of the screen, the smallest material passes from the beginning to the middle and finally the largest. In this way, it makes dissimilar classes of fruits such as orange, apple, and vegetables like tomato and potato



Figure 1.10: Potato and Orange screens machines grader

1.2- Examining characteristics of produce and confirming grading purpose

1.2.1 Examine characteristics of produce (fruit and vegetable)

Fruit maturity degree is significant as industrial maturity is required for some processing / preservation methods while for others there is the need for an edible maturity when the fruit has full taste and flavor. Special attention is given to size, appearance and uniformity of fruit to be processed. Temporary storage before processing has to be as short as possible in order to avoid: flavor Losses, texture modification, weight losses and other deterioration that can take place over this period. Fresh Fruits and Vegetables at reception mostly check the following character:

- Color
- Texture
- Taste
- Flavour
- Appearance
- Refractometer extract
- Variety
- Sanitary evaluation
- Density
- Total sugars
- Total acidic

Once it has left the tree, the organoleptic properties, nutritional value, safety and aesthetic appeal of the fruit deteriorates in varying degrees. The major causes of deterioration include the following:

- Growth and activity of micro-organisms
- Activities of the natural food enzymes
- Insects, parasites and rodents
- Temperature, both heat and cold
- Moisture and dryness
- Air and in particular oxygen
- Light and time

Vegetables varieties: Vegetable processors must appreciate the substantial differences that varieties

of a given vegetable will possess. In addition to variety and genetic strain differences with respect to weather, Insect and disease resistance, varieties of a given vegetable will differ in size, shape, time of maturity, and resistance to physical damage.

When vegetables are maturing in the field they are changing from day to day. There is a time when the vegetable will be at peak quality from the stand-point of color, texture and flavour. This peak quality is quick in passing and may last only a day. Harvesting and processing of several vegetables, including tomatoes, corn and peas are rigidly scheduled to capture this peak quality. After the vegetable is harvested it may quickly pass beyond the peak quality condition. This is independent of microbiological spoilage; these main deteriorations are related to:

a. Loss of sugars due to their consumption during respiration
b. Production of heat when large stockpiles of vegetables are transported or held prior to processing. At room temperature some vegetables will liberate heat at a rate of 127,000 kJ/ton/day this is enough for each ton of vegetables to melt 363 kg of ice per day
c. Since the heat further deteriorates the vegetables and speeds micro-organisms growth, the harvested vegetables must be cooled if not processed immediately.

But cooling only slows down the rate of deterioration, it does not prevent it, and vegetables differ in their resistance to cold storage. Each vegetable has its optimum cold storage temperature which may be between about 0-10^{0}C. The continual loss of water by harvested vegetables due to transpiration, respiration and physical drying of cut surfaces results in:

a) Wilting of leafy vegetables
b) Loss of plumpness of fleshy vegetables
c) Loss of weight

In many processing plants it is common practice to process vegetables immediately as they are received from the field. To ensure a steady supply of top quality produce during the harvesting period the large food processors will employ trained field men; advise on growing practices and on spacing of plantings so that vegetables will mature and can be harvested in rhythm with the processing plant capabilities. This minimizes stockpiling and need for storage. Varietal differences

then further extend into warehouse storage stability, and suitability for such processing methods as canning, freezing, pickling or drying. **Additionally,** See characteristics of fruits and vegetables on this link: **(https://www.youtube.com/watch?v=E2SffOEUJM4 , Accessed Date, Nov 30, 2023)**

General quality attributes of fruits and vegetables are:

a) The appearance of fruits and vegetables

The appearance of fruits and vegetables is a crucial factor that influences consumer perception, purchasing decisions, and overall product quality. Here are some key considerations related to the appearance of fruits and vegetables:

Color: The color of fruits and vegetables is often an important indicator of their ripeness, freshness, and nutritional value. Vibrant, uniform colors are generally associated with desirable quality. For example, bright red tomatoes or rich green spinach are often preferred by consumers.

Size and shape: The size and shape of fruits and vegetables can vary widely, even within the same variety. Customers may have preferences for specific sizes or shapes based on their culinary needs or aesthetic preferences. Uniformity in size and shape can also contribute to a visually appealing display. Texture and Surface: The texture and surface characteristics of fruits and vegetables can influence their perceived freshness and quality. Customers often look for produce that is smooth, firm, and free from blemishes, bruises, or wrinkles. A glossy or shiny surface can also be an indicator of freshness.

Symmetry and uniformity: Consistency and uniformity in the appearance of fruits and vegetables can enhance their visual appeal. Customers may prefer produce that exhibits symmetrical shapes and consistent color distribution.

Blemishes and defects: The presence of blemishes, bruises, or other defects can detract from the appearance of fruits and vegetables. Customers generally prefer produce that is free from major imperfections, as they associate blemish-free items with better quality.

Freshness Indicators: Certain fruits and vegetables have specific freshness indicators that customers look for. For example, the leaves of fresh lettuce should be crisp and green, while the stem of a fresh pineapple should be green and firm.

Packaging and presentation: Packaging can play a significant role in enhancing the appearance of fruits and vegetables. Clear packaging that allows customers to see the produce, attractive labels or branding, and proper arrangement can contribute to a visually appealing presentation.

It's important to note that while appearance is an important factor, it should be considered alongside other quality indicators such as taste, aroma, and nutritional value when assessing the overall quality of fruits and vegetables.



Figure 1.11: Choosing vegetables and fruit
(https://www.youtube.com/watch?v=LbWNHxkjwFE , Accessed: Nov 30, 2023)

b) The texture of fresh fruits and vegetables

The texture of fresh fruits and vegetables can vary depending on the specific type of produce. Here are some common texture characteristics found in fresh fruits and vegetables:

Firm and crisp: Many fresh fruits and vegetables have a firm and crisp texture when they are at their peak of freshness. Examples include apples, carrots, celery, radishes, and cucumbers. These produce items are known for their satisfying crunch when bitten into.

Tender and juicy: Some fresh fruits and vegetables have a tender and juicy texture, characterized by a soft and succulent flesh. Examples include ripe peaches, plums, grapes, tomatoes, and leafy greens like lettuce and spinach. These items are often appreciated for their juiciness and delicate mouthfeel.

Smooth and creamy: Certain fresh fruits and vegetables have a smooth and creamy texture, offering a rich and velvety mouthfeel. Examples include avocados, bananas, and ripe melons. These produce items are known for their buttery or custard-like consistency.

Fibrous: Some fresh fruits and vegetables have a fibrous texture, containing noticeable fibers or strings within their flesh. Examples include pineapples, oranges, asparagus, and some varieties of mangoes. These items may require more chewing and can provide a unique textural experience.

Soft and delicate: Fresh fruits and vegetables that are fully ripe or nearing ripeness may have a soft and delicate texture. Examples include ripe pears, kiwifruits, apricots, and tomatoes. These items are often characterized by their tender and easily yielding flesh.

Grainy: Certain fresh fruits have a grainy texture, with small granules or particles within their flesh. Examples include pears, guavas, and some varieties of apples. These fruits offer a slightly gritty or sandy sensation when eaten.

Crispy and watery: Some fresh vegetables, such as bell peppers, snap peas, and radishes, have a crispy texture combined with a high water content. These items provide a refreshing and hydrating crunch when consumed.

It's important to note that the texture of fresh fruits and vegetables can change as they ripen or age. Additionally, specific varieties and cultivars of fruits and vegetables may exhibit unique texture profiles. The desired texture can vary depending on personal preference and the intended culinary use of the produce.



Figure 1.12: Texture of fruits and vegetables ()

c) The flavor of fresh fruits and vegetables

The flavor of fresh fruits and vegetables can vary widely, with each type of produce offering its own distinct taste profile. Here are some common flavor characteristics found in fresh fruits and vegetables:

Sweet: Many fruits are known for their natural sweetness. Examples include strawberries, grapes, pineapples, watermelons, and mangoes. These fruits often have a pleasant, sugary taste that is generally well-liked.

Tart or sour: Some fruits and vegetables have a tart or sour flavor, which can add a refreshing and tangy element to dishes. Examples include lemons, limes, oranges, grapefruits, and certain types of apples. These items often have a noticeable acidity that can provide a pleasant contrast to sweetness.

Bitter: Certain vegetables, particularly leafy greens and cruciferous vegetables, have a bitter flavor

profile. Examples include kale, arugula, radicchio, and broccoli rabe. Bitterness can add complexity and depth to dishes, and it is often balanced with other flavors.

Earthy: Some vegetables have an earthy flavor, reminiscent of the soil in which they are grown. Examples include beets, mushrooms, carrots, and radishes. These items often have a slightly nutty or root-like taste that can be quite distinct.

Herbaceous: Several herbs and certain vegetables have an herbaceous flavor, characterized by a fresh and aromatic quality. Examples include basil, cilantro, parsley, and celery. These items often contribute a vibrant and green taste to recipes.

Mild or subtle: Some fruits and vegetables have a mild or subtle flavor, meaning they are not overpowering or strongly pronounced. Examples include cucumbers, zucchinis, iceberg lettuce, and some varieties of melons. These items provide a neutral or delicate taste that can complement other ingredients.

Peppery or Spicy: Certain vegetables, such as radishes, arugula, and peppers, can have a peppery or spicy flavor. These items often offer a pleasant heat or bite that adds depth and complexity to dishes.

It's important to note that flavor can vary within each type of fruit or vegetable, depending on factors such as ripeness, growing conditions, and variety. Additionally, personal preferences for flavor can vary widely, with some individuals favoring sweetness, while others prefer more savory or tangy tastes.



Figure 1.13: Adding flavor to fruit and vegetable

d) The taste of fresh fruits and vegetables

The taste of fresh fruits and vegetables can vary depending on various factors such as ripeness,

variety, and growing conditions. Here are some key points about the taste of fresh fruits and vegetables based on the search results:

Taste perception: Taste is a subjective experience, and individual preferences can vary. Some people may naturally enjoy the taste of fruits and vegetables, while others may find them less appealing.

Flavor combination: The taste of fruits and vegetables is not solely determined by their taste buds but also by a combination of factors including smell and the trigeminal nerve, which contributes to the perception of thermal, mechanical, and chemical senses.

Taste Buds: Our taste buds, located on different zones of the tongue, allow us to identify primary flavors. The tip of the tongue senses sweetness, the sides detect saltiness and acidity, and the back of the tongue identifies bitterness. Additionally, there is the fifth flavor, umami, which is associated with savory tastes.

Ripeness and sugar content: The taste of fruits, such as strawberries, is directly related to their ratio of sugar to acidity. Fruits harvested prior to maturity may have less sugar content, resulting in a less pleasing taste.

Varieties and growing conditions: Different varieties of fruits and vegetables can have distinct flavors. Factors such as soil quality, climate, and cultivation practices can also influence the taste of fresh produce.



Figure 1.14: Types of food taste

e) The aroma of fresh fruits and vegetables

The aroma of fresh fruits and vegetables is an important aspect of their sensory experience. The aroma, or fragrance, of these produce items can vary significantly, contributing to their overall appeal. Here are some common aroma characteristics found in fresh fruits and vegetables:

Fruity: Many fruits have a distinct fruity aroma that is often sweet and enticing. Examples include

strawberries, oranges, pineapples, bananas, and peaches. These fruits emit a pleasant and inviting fragrance that is associated with their natural flavors.

Citrusy: Citrus fruits are known for their vibrant and refreshing citrusy aroma. Examples include lemons, limes, grapefruits, and tangerines. These fruits emit a zesty and tangy fragrance that is often invigorating.

Floral: Some fruits and vegetables have a delicate floral aroma, reminiscent of flowers. Examples include melons, lychees, and certain varieties of apples. These items offer a subtle and fragrant scent that can be quite pleasing.

Herbaceous: Certain herbs and vegetables have an herbaceous aroma, characterized by a fresh and green fragrance. Examples include basil, mint, cilantro, and parsley. These items emit a distinct herbal scent that is often associated with freshness.

Earthy: Some vegetables have an earthy aroma, evoking the scent of the soil in which they are grown. Examples include beets, mushrooms, carrots, and potatoes. These vegetables emit a distinct and grounding fragrance that is often appreciated in savory dishes.

Spicy or Pungent: Certain vegetables, such as onions, garlic, and radishes, have a spicy or pungent aroma. These items emit a strong and distinctive scent that can add depth and flavor to various culinary preparations.

Grassy: Certain leafy greens, like spinach and arugula, have a fresh and grassy aroma. These greens often emit a green and vegetal scent that is associated with their vibrant color and freshness. It's important to note that the aroma of fresh fruits and vegetables can vary depending on factors such as ripeness, variety, and growing conditions. Additionally, individual preferences for aroma can vary, with some individuals favoring sweet and fruity scents, while others prefer more earthy or herbaceous aromas.

Ripeness and aroma: The aroma of fruits and vegetables can change as they ripen. Many fruits, such as bananas and mangoes, emit a stronger and more pronounced aroma when fully ripe. This is often an indicator of peak flavor and sweetness. On the other hand, certain vegetables, like broccoli and Brussels sprouts, may develop a stronger aroma as they become overripe.

Volatile compounds: The distinct aromas of fruits and vegetables are primarily due to the presence of volatile compounds. These compounds are responsible for the characteristic scent and

can vary among different types of produce. For example, esters are often responsible for fruity aromas, while terpenes contribute to citrusy and floral scents.

Varietal differences: Within each type of fruit or vegetable, there can be varietal differences in aroma. For instance, different apple varieties can have varying levels of sweetness and fragrance. This diversity provides a range of aromatic experiences and allows for experimentation in cooking and flavor pairings.

Seasonal variations: The aroma of fruits and vegetables can also be influenced by seasonal variations. For example, certain fruits like strawberries and cherries are known for their intense and enticing aromas during their peak seasons. Seasonal factors can impact the overall quality and aroma of produce.

Harvesting and storage: Proper harvesting and storage practices can play a role in preserving the aroma of fresh fruits and vegetables. Harvesting produce at the optimal stage of ripeness and storing it under appropriate conditions can help maintain its aroma until it reaches the consumer.

Aroma and Flavor Connection: The aroma of fruits and vegetables is closely linked to their flavors. The volatile compounds that contribute to their distinctive scents also play a significant role in the overall flavor profile. The aroma enhances the perception of taste, as our olfactory senses work in conjunction with our taste buds to create a more complete sensory experience.

Overall, the aroma of fresh fruits and vegetables adds depth, complexity, and sensory appeal to our culinary experiences, making them a delightful and enticing part of our meals.



Figure 1.15: Quality evaluation of fruits and vegetables
(https://www.youtube.com/watch?v=R5H0mcD7F5E , Accessed date, Nov 30, 2023)

Climacteric and non-climacteric fruit: Climacteric and non-climacteric fruits are two

categories based on their ripening patterns and response to ethylene gas. Understanding these categories can help in proper storage and handling of fruits.



Figure 1.16: Climacteric and non-climacteric fruit

(https://www.youtube.com/watch?v=M04qyi_PyS0 , Accessed Date: Nov, 2023)

Climacteric fruits: Climacteric fruits are capable of ripening even after being harvested. They exhibit a significant increase in ethylene production during the ripening process. Ethylene is a natural plant hormone that triggers and promotes ripening. Some examples of climacteric fruits include bananas, tomatoes, pears, mangoes, peaches, apples, and avocados.

Climacteric fruits can be harvested when they are still green and then artificially ripened by exposing them to ethylene gas. This is often done in supply chains to ensure that the fruits reach the desired ripeness before being sold to consumers.

Non-Climacteric Fruits: Non-climacteric fruits, on the other hand, do not continue to ripen after being harvested. They have a lower ethylene production and do not respond to ethylene gas in the same way as climacteric fruits. Examples of non-climacteric fruits include citrus fruits like grapefruit and lemon, berries such as raspberry, strawberry, and cherry, grapes, pineapple, melon (including watermelon), and pomegranate.

Non-climacteric fruits should be allowed to fully ripen on the plant before being harvested, as they will not ripen further once picked.

Storage and handling: Proper storage and handling of climacteric and non-climacteric fruits are important to maintain their quality and prevent spoilage. Here are some key points:

Climacteric fruits can be stored at room temperature to ripen further, while non-climacteric fruits should be stored in the refrigerator to maintain their freshness.

It is important to store climacteric fruits separately from non-climacteric fruits, as the ethylene produced by climacteric fruits can accelerate the ripening and spoilage of non-climacteric fruits.

Damaged or overripe fruits, regardless of their category, should be used first to prevent them from affecting the quality of other fruits.

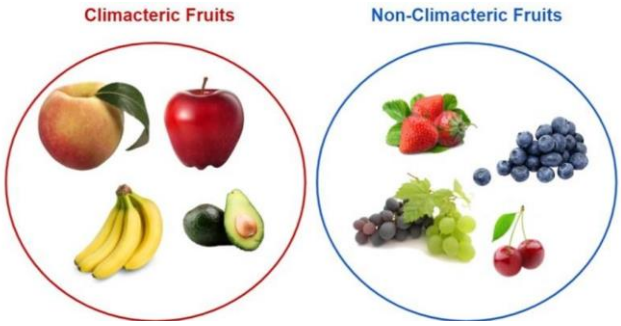


Figure 1.17: Climacteric and non-climacteric fruit

1.2.2 Confirming grading purpose of fruit and vegetable

Grading is basically separating the fruit and vegetable in different homogenous groups according to its specific characteristics like size, shape, color and on quality basis. It saves time and energy in different processing operations and separates immature, over- mature, scarred and damaged fruits.

Purpose:

- Reduction of variability
- Have all fruit fit the holes of the liners
- Provide customers with desired sizes
- It saves time and energy in different processing

Grading attributes: Grading attributes are the physical characteristics used to categorize fruits and vegetables based on their quality and market value. These attributes help determine the grade or classification of the produce. Here are some common grading attributes used for fruits and

vegetables:

Weight: The weight of the fruit or vegetable is an important attribute for grading. It helps determine the size and maturity of the produce. Different grades may have specific weight ranges.
Size: The size of the fruit or vegetable is another important attribute for grading. It is usually measured in terms of diameter, length, or weight. Grading based on size ensures uniformity and consistency in the produce.
Colour: The colour of the fruit or vegetable is an important visual attribute that affects consumer preference. Vibrant and attractive colours are often preferred in the market. The colour can also indicate the ripeness or freshness of the produce.
Shape: The shape of the fruit or vegetable can vary, and certain shapes may be preferred for specific purposes or markets. Grading based on shape helps ensure consistency and suitability for different uses.
Specific gravity: Specific gravity is a measure of the density of the fruit or vegetable. It is often used to determine the maturity and quality of certain produce, such as citrus fruits.
Freedom from diseases: Grading also takes into account the presence of diseases or damage on the produce. Fruits and vegetables that are free from diseases, insect damage, or physical defects are usually graded higher.

These grading attributes are used to categorize fruits and vegetables into different grades, such as Extra Class, Class I, and Class II, based on their quality and market standards.



Figure 1.18: Graded and sorted fruits based on grading attributes

1.3- Confirming customer and packaging requirements

1.3.1 Confirming customer requirements

Fresh fruit and vegetables requires to keep high standards of food safety and quality.

In general sense, quality is defined as degree of excellence. Quality is

- Fitness for use
- Conformance to requirement
- Performance to the standard, expect by the consumer
- Meeting the customer need, the first time and every next time
- Quality is meeting or exceeding customers exception

Minimum quality specifications for fresh fruit and vegetables in all classes, subject to the tolerances allowed, the produce must be:

- Intact; however, the following is allowed, provided the edibility and keeping quality is not affected:
- Hollowness provided the surrounding tissue is sound, fresh and not discolored
- Slight damages and cracks
- Missing peduncle/calyx provided the adjacent tissue is not damaged
- Sound; produce affected by rotting or deterioration such as to make it unfit for consumption is excluded
- Clean, practically free of any visible foreign matter
- Practically free from pests
- Practically free from damage caused by pests
- Free of abnormal external moisture
- Free of any foreign smell and/or taste



Figure 1.19: Apple fruit defect

1.3.2 Confirming packaging requirements

Packaging fresh fruits and vegetables are one of the more important steps in the long and complicated journey from grower to consumer. Bags, crates, hampers, baskets, cartons, bulk bins, and palletized containers are convenient containers for handling, transporting, and marketing fresh produce.

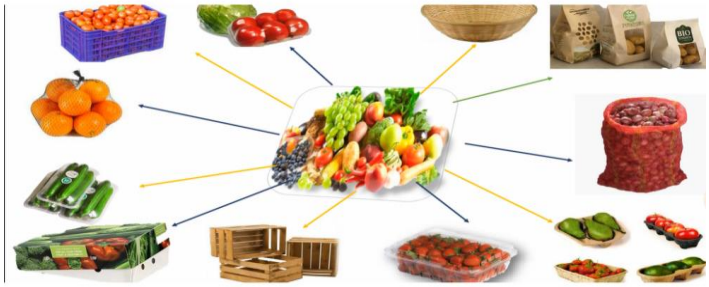


Figure 1.20: Packaging fresh fruits and vegetables
(https://www.youtube.com/watch?v=v3MlUYV6Q0U, https://www.youtube.com/watch?v=Fy4l04-7soI , Accessed, Date: Nov 30, 20233)

Packaging fresh fruits and vegetables is one of the more important steps in the long and complicated journey from grower to consumer. Bags, crates, hampers, baskets, cartons, bulk bins,

and palletized containers are convenient containers for handling, transporting, and marketing fresh produce.

Packaging is constantly changing with the introduction of new materials, technology and processes. These may be due to the need for improved product quality, productivity, logistics service, environmental performance and profitability. A change in packaging materials, however, may have implications for consumer acceptance. The aim is a fitness for purpose approach to packaging design and development that involves selection of the most appropriate materials, machinery and production processes for safe, environmentally sound and cost effective performance of the packaging system. Packaging should be designed to prevent physical damage to produce, and be easy to handle. A properly designed produce container should contain, protect, and identify the produce, satisfying everyone from grower to consumer.

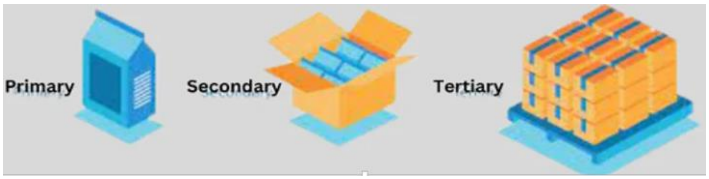


Figure 1.21: Product packaging | functions | types of the product packaging (https://www.youtube.com/watch?v=SEnphKq9f9c , Accessed: Dated, Nov 30, 2023)

The most important points packaging requirements are:

- Recyclability/biodegradability - most produce packaging are going to be recyclable or biodegradable, or both.
- Variety- different sizes and designs of produce packages
- Sales appeal - spice up sales appeal
- Shelf life- every commodity to increase time period and reduce waste
- Containment-the container must enclose the produce in convenient units for handling and distribution.
- Protection- protects the produce from mechanical damage and poor environmental conditions during handling and distribution. to supply buyers, torn, dented, or collapsed produce packages usually indicate lack of care in handling the contents.

- Identification- identify and supply useful information about the produce

Modified atmospheric packaging for fruit and vegetable:-

- Closed package with selectively permeable film
- Film types

✓ High permeability ✓ Micro perforated

✓ Low permeability

- CO2 increases, O2 decreases
- Avoid fermentation

✓ Permeability not too low ✓ Temperature stability

- High relative humidity

✓ Limited moisture loss ✓ Condensation risk



Figure 1.22: Different Packaging requirements for fresh fruits and vegetables

1.4 Determine specifications for grading

1.4.1 Determining grading specifications

Grade standards provide the fruit and vegetable industry with a uniform language for describing the quality and condition of commodities. Current grade standards for fruits and vegetables use attributes based on sensory characteristics, shelf-life considerations, palatability, or a combination of these factors. During recent years "health consciousness" has increased among consumers. Furthermore, a growing number of studies has demonstrated health benefits from various nutrients contained in relatively large amounts in fruits and vegetables). Consequently, questions arise about

the feasibility and desirability of incorporating nutrient attributes into current standards or replacing the current sensory-based standards with nutrient based standards.

Tolerances are legal limits on unacceptable size, quality, and condition grading factors. Tolerances generally are stated in percentage terms and can vary by product, use, or size of the individually packaged product. For example, the tolerances for U.S. Number 1 apples for processing illustrate the variety of forms that tolerances can take:

- No more than 10 percent of apples with quality and condition defects including no more than 2 percent of apples with decay,
- Percent with internal breakdown and 5 percent with wormholes, and
- The apples cannot be further advanced in maturity than generally firm ripe

Grading factors listed in standards for fresh and processed fruits and vegetables can be broadly divided into four main categories

1) Size
2) Quality
3) Condition
4) Tolerances

Size can be described by diameter, length, weight, and uniformity of sizing

Quality factors defined as "the combination of the inherent properties or attributes of a product which determines its relative degree of excellence generally refer to attributes that remain permanent once the commodity is harvested or processed. Examples include variety, cleanliness, and shape for fresh fruits and vegetables; and color, clarity, and flavor and aroma for processed fruits and vegetables.

Condition refers to**:** "the relative degree of soundness of a product which may affect its merchantability and includes those factors which are subject to change and may result from but not necessarily limited to age, improper handling, storage or lack of refrigeration.

Tolerances are legal limits on unacceptable size, quality, and condition grading factors. They generally are stated in percentage terms and can vary by product, use, or size of the individually packaged product. Size, quality, and condition grading factors have three elements in common:

a) Measurable or observable,
b) There is a common body of knowledge which allows a widespread acceptance of how the factor will be applied in determining the grade, and
c) The factor varies among individual specimens of the commodity.

The existence of tolerances reflects this variability by allowing a sample to obtain a given grade even though all specimens in the sample do not meet minimum quality, condition, and size.

Cabbages of all grades must:

(a) be properly packaged;
(b) have similar varietal characteristics;
(c) be trimmed so that the butts are no longer than 13 mm (½ inch) and there are no more than six wrapper leaves per head
(d) have heads that are not withered or burst
(e) have heads that do not plainly show the formation of a seed stem; and
(f) be free from decay

No. 1 Grade Requirements:

In addition to meeting the requirements for all grades, cabbages graded No. 1 must

(a) have, in the case of cabbages of the Savoy type, heads that are not soft;
(b) have, in the case of cabbages of types other than Savoy, heads that yield only slightly to pressure;
(c) have all outer leaves that are damaged by worms, disease or other factors removed;
(d) if prepackaged, not vary by more than 51 mm (2 inches) in diameter; and
(e) Be free from any other damage, defect or combination of damage and defects that materially affects the appearance, edibility or shipping quality of the cabbages.

No. 2 Grade Requirements:

In addition to meeting the requirements for all grades, cabbages graded No. 2 must

A. have heads that are not soft; and

B. be free from any other damage, defect or combination of damage and defects that

i. seriously affects the appearance, edibility or shipping quality of the cabbages, or

ii. Cannot be removed without the loss of more than 15% of the edible portion of a head of cabbage.

General Tolerances:

In the grading of cabbage, the requirements, as applicable, are considered to be met in the case of a lot of cabbage when not more than

- In the case of a lot of cabbage inspected at the time of shipping or repackaging, 10%, by count, of the cabbages in the lot have defects, including not more than

(i) 2% that are affected by decay, and

(ii) 5% that have the same defect other than decay; and

- In the case of a lot of cabbage inspected at a time other than at the time of shipping or repackaging, 10%, by count, of the cabbages in the lot have permanent defects, including not more than 5% that have the same permanent defect. Condition defects apply against the grade of a lot of cabbage only when the lot is inspected at the time of shipping or repackaging.

Self-check #1	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Write true if the statement is correct and false if the statement is incorrect

1. Drum type fruit and vegetable grading machine is suitable for grading and sorting of irregular shape fruits and vegetables
2. In general sense, quality is defined as degree of excellence

Test II: Choose the best answer among the given alternative

1. Which one not of are grading machines for fruits and vegetable
   (a) Diverging Belt Grade
   (b) Roller Grader
   (c) Screens Grader ,
   (d) Sorting
2. Which of the following type of graders is fast, precise and reasons little damage to fruit? (2 pts
   (a) Roller Grader grader
   (b) Belt grader
   (c) Screens Machines Grader
   (d) all
3. Volatiles released by fruit / vegetable and perceived by olfactory epithelium on tongue is?
   (a) Colour
   (b) Ripeness
   (c) Aroma
   (d) All
4. Which character fresh fruits and vegetables checks at reception? (2pts)
   (a) Color
   (b) Texture
   (c) Taste
   (d) All
5. The purpose of different processing operations and separates immature, over- mature, scarred and damaged fruits:
   (a) Reduction of variability
   (b) Have all fruit fit the holes of the liners

(c) Provide customers with desired sizes (d) All

6. Which criteria does the grading machine primarily use to classify oranges?

(a) Size (c) Quality

(b) Color (d) All of the above

7. How does the grading machine assess the color of oranges?

(a) Optical sensors (c) Both a and b

(b) Manual inspections (d) None of the above

Test III: Write short answer for the following questions

1. Write minimum quality specifications for fresh fruit and vegetables?
2. List and describe the types of grading machines for fruits and vegetables
3. Define the following terms?
   a. Safety
   b. Freshness

Operation Sheet 1

1.1 Techniques grading process of mango fruit

Objective: To attain best quality and free defects of mango fruit

A. Equipment and tools:

- Scissor
- Clean water
- Washer machine
- Grader machine
- Mango fruit

B. Procedure:

Sorting and grading procedure of Mango

- Rinse of mango fruit
- Cleaning /washing of mango fruit
- Apply vapour heat treatment of mangoes at 46 oC for 10 min
- Sort and grading mango fruit manual/ mechanically
- Set the grade according to the minimum requirements of mango
- Package and label mango fruit

1.2 Techniques of operating orange grading machine

Objective:

To understand the grading operation of orange grading machine

A. Equipment and tools:

- Orange Grading Machine
- Conveyor System
- Sizing Rollers or Screens
- Optical Sensors or Cameras
- Quality Inspection Equipment
- Bins or Containers
- **Personal Protective Equipment (PPE)**

B. Procedure:

Procedure of operating orange grading machine

- Ensure that the grading machine is clean and in proper working condition
- Calibrate the grading machine according to the desired grading standards
- Place the oranges onto the feeding mechanism of the grading machine.
- Grade the oranges by pass through a series of sizing rollers or screens that separate them based on their diameter or circumference.
- Grade the color the oranges using optical sensors or cameras.
- Inspect the quality of the oranges through automated systems that analyze characteristics such as blemishes, bruises, decay, and overall appearance.
- Sort and pack after the oranges graded into different bins or containers based on their size, color, and quality grades.

LAP TEST 1	Performance test

Name…… ID……Date……

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 6 hour. The project is expected from each student to do it.

Task 1: Perform grading of mango

Task 2: Perform and grade of oranges using orange grading machine.

LG #2	LO -2 Program grading equipment

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Entering Specifications and setting grading parameters.
- Using equipment components to enable a variety of grading.
- Testing equipment operation.
- Investigating problems and implementing corrective action
- Completing documentation and Recording grading specifications for customer.

This guide will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Enter Specifications and setting grading parameters.
- Use equipment components to enable a variety of grading.
- Test equipment operation.
- Investigate problems and implementing corrective action
- Complete documentation and Recording grading specifications for customer.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test” If

Information Sheet 2

2.1 Entering specifications and setting grading parameters

2.1.1 Entering specifications into computer to set grading parameters

Computer Vision (CV) is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control and robot guidance in industrial applications. While the scope of CV is broad and a comprehensive definition is difficult to distil, a generally accepted definition of computer vision is „the analysis of images to extract data for controlling a process or activity". Size, shape and color analysis:

Equipment

- Cameras
- infra-red lights
- lasers
- temperature gauges and conveyor belts



Figure 2.1: Camera high speed fruit sorting

Size, which is the first parameter identified with quality, has been estimated using machine vision by measuring projected area, perimeter or diameter. Size measurement is important for

determining produce surface area.

The shape is one of the important visual quality parameters of fruits, vegetables, etc. Currently human sorters are employed to sort fruits based on shape. Shape is a feature, easily comprehended by human but difficult to quantify or define by computer. Most of the machine vision shape detection work has been done on industrial objects, which have definite structure. Fruit and vegetable are unique in nature and the growing environment causes various boundary irregularities which influences their shapes. Image processing offers solution for sorting of fruits based on their shape.

Colour is also an important quality factor that has been widely used. The colour of an object is determined by wavelength of light reflected from its surface. In biological materials the light varies widely as a function of wavelength. These spectral variations provide a unique key to machine vision and image analysis.

The fruits sorting and grading are considered the most important steps of handling. Sorting and grading are major processing tasks associated with the production of fresh market fruit, vegetable and crop type.

The image processing can be highly applied on agricultural applications for various purposes like:

i. To detect diseased leaf, stem, fruit and roots.
ii. To determine size & shape of fruits and plant.
iii. To estimate chlorophyll content of a plant.
iv. Measurement of plant leaf area.
v. Weed detection

The image related parameters colour, size, and shapes are found in real time and the fruits are graded and sorted as per user requirement.

Machine vision based sorting system consists of a computer and video cameras to perceive fruit images, process their images, and make suitable inspection decisions. Grading decisions required

in many agricultural processes, which are otherwise difficult, can be taken up by machine vision. Computer mission vision system essentially involves three main processes namely image acquisition, image processing and decision-making. Cameras under appropriate lighting conditions carry out image acquisition. The visual information is converted from analog to digital format. The acquired images are analyzed by image processing hardware and/or software to extract the required object features and quality parameters. Based on these results, a decision on the fruit quality is taken by software considering the end user's requirements.

Size: The fruit size is another quality attribute used by farmers - the correct size fruit is considered of better quality. The size is estimated by calculating the area covered by the fruit image. To compute the area, first the fruit image is binarized to separate the fruit image from its background. Consider following picture is a original picture captured by camera, this was taken by Open CV to find shape by background extraction function.



Figure 2.3: Mango picture captured by camera to determine size and shape

Shape: The farmers use shape irregularity as a quality measure. Fruits having regular shapes are considered of better quality. It estimated from the outer profile of the fruit image. Using an edge tracking operator can estimate the out most edge points of the fruit image. Have many edge detecting techniques in this canny edge detector is used to detect the edges.

Colour: Colour based identification is important to grade the fruits. The easiest way to detect and segment an object from an image is the colour based methods. The colors in the object and the background should have a significant colour difference in order to segment objects successfully using colour based methods. In database already all the data's are stored to find required one. As

per required the Open CV libraries, distributed by us, on the Microsoft Windows operating system are in a Dynamic Linked Libraries (DLL). These have the advantage that all the content of the library are loaded only at runtime, on demand, and that countless programs may use the same library file. This means you have ten applications using the Open CV library, no need to have around a version for each one of them. But need to have the DLL of the Open CV on all systems where you want to run the application.



Figure 2.4: Mango grading using colour

2.2 Using equipment components to enable a variety of grading.

2.2.1 Using equipment components to enable grading out comes

Sorting Table: The Bellmer sorting table offers an optimal visual control of process. At this point the sorting table allows the user to observe the quality of the products visually. Accordingly, the user overviews the complete procedure and can quickly sort out bad products or leaves. This process step influences the quality of the end product and the later process steps. Generally, the sorting table for the sorting of the raw material is installed before the crushing process. Moreover, due to food handling, it is made of stainless steel and adapted to hygiene standards.

Besides, the sorting table includes a spraying device to clean the products from impurities with fresh water. Here the spray water quantity is adjustable by manual valves. Also, a synthetic band of the sorting table is equipped with a scraper for easy removal of adherent dirt. Furthermore, it allows the user to adjust the speed of the sorting band. With our know-how and experiences in project planning, we recommend you the right equipment for your application. The Bellmer sorting table is easy to clean and maintain and simplifies your

sorting procedure



Figure: 2.5: Sorting table for fruits

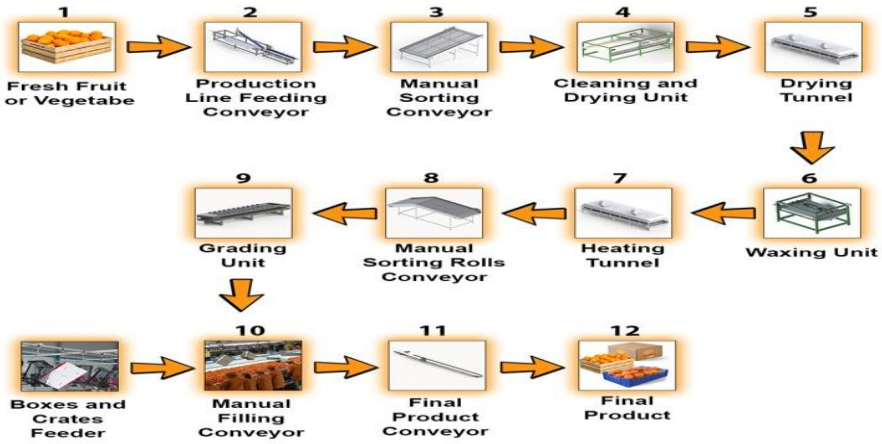


Figure 2.6: cleaning, sorting and grading line

The crucial sensory characteristic of fruits and vegetables is appearance that impacts their market value, the consumer's preference and choice. Although, the sorting and grading can be done by human but it is inconsistent, time consuming, variable, subjective, onerous, expensive and easily influenced by surrounding. Hence, an astute fruit grading system is needed. In recent years, various algorithms for sorting and grading are done by various researchers using computer vision. This paper presents a detailed overview of various methods i.e. preprocessing, segmentation, feature extraction, classification which addressed fruits and vegetables quality based on color, texture, size, shape and defects. In this paper, a critical comparison of different algorithm proposed by researchers for quality inspection of fruits and vegetables has been carried out.

Components of optical color sorter for fruit and vegetable sorting

Customized image algorithm Advanced image algorithm, which can customize specific algorithm according to different sorting materials: color sorting and shape sorting available.

Electronic / camera grading (**https://www.youtube.com/watch?v=1W4f3JComTg, Accessed date, November 30/2023)**

Full color CCD cameras: Angel on vision system converts the captured targets into image signals through CCD cameras, and then transmits the signals to a dedicated image processing system. The 2048*∞pixels grade high resolution CCD color cameras with sharpness up to 0.01mm2 can identify subtle color differences and defects successfully.

Lower damage ratio by Belt-type structure design

Horizontal transporting by uniform and stable conveyor makes less collision for the materials. So that its damage ratio is much lower than that of traditional chute-type color sorter.

Intelligent real-time display of actual material image: Real-time checking the targets marking situation is available on the 21-inch LED computer screen through the real-time display system of actual material image, which is easy for engineers to adjust sorting parameters both on site and by remote.

Long life and full color LED light source: With uniform color, high brightness, and long life when using the white LED light source in our full color sorters.

Remote interconnection system: Remotely diagnoses each color sorter and assist with equipment operation are available after obtaining customers‟ authorization.

Precise target technology: Remotely diagnoses each color sorter and assist with equipment operation are available after obtaining customers‟ authorization.

Precise target technology: Accurately identify materials‟ defects and impurities, and blow the target defects through the combination of the latest CCD cameras and target positioning program, which can increase the sorting accuracy and reduce the optimized carryover a lot.
High-quality customized valves
With high frequency and strong motivation, they can accurately blow off some high density materials like minerals, waste metal flakes, etc.
Uniform feeding system

Different vibrators are used for different materials. Angelon used motor vibrators and electromagnetic vibrators to ensure smooth feeding for different materials.



Figure 2.7: Optical color sorter

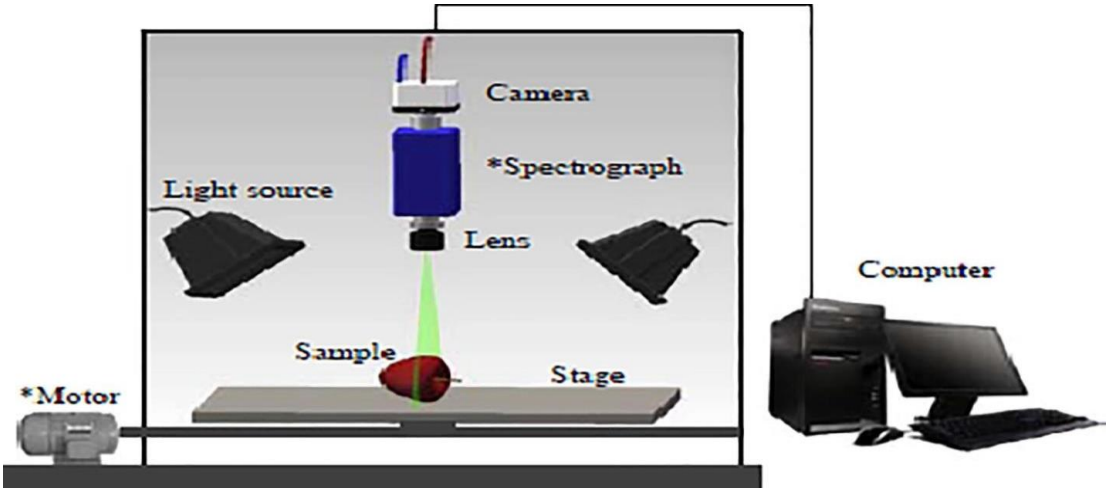


Figure 2.8: A classical computer vision system

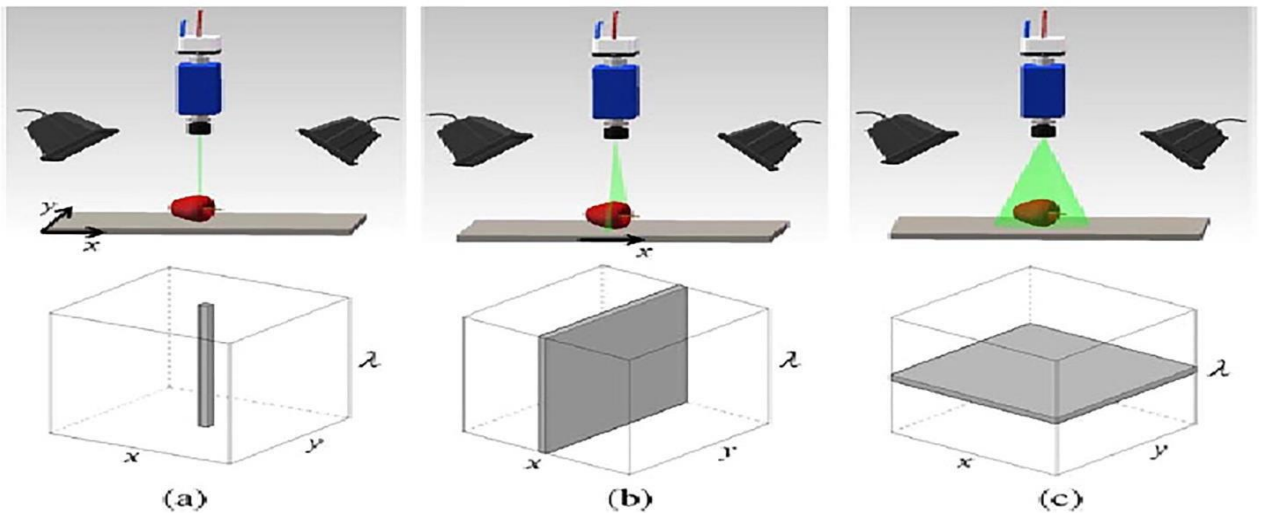


Figure 2.9: Hyper spectral image scanning mode (a) Point scanning (b) Line scanning (c) Area scanning



Figure 2.10: Blueberry color sorted by Optical Color Sorter



Figure 2.11: Vegetable based color sorting

2.3 Testing equipment operation

2.3.1 Testing and monitoring program:

Fruits and vegetables are powerhouse of essential vitamins, minerals, anti-oxidants, thiamine, niacin, pyridoxine, folic acid, and dietary fiber but do you know that it can be contaminated with harmful substances pre-harvest by animals, insects, water, soil, dirty equipment, and poor human handling.

Further they can be contaminated by unclean water for washing, packing materials, process equipment, and dirty transportation vehicles. Food Safety and Standards Authority of India (FSSAI) has set the standards for fruits and vegetables that all food businesses must comply with if food safety and quality are to be maintained. However, there is no way to detect harmful substances or find out if fruits and vegetables are within standards unless they are tested in a food laboratory.

The mind full eating food choices and market trends shows that consumers are increasingly driven towards eating fresh vegetables and fruits.

Besides there is an upsurge of processed food and vegetables one of the important criteria for evaluating the quality of fruits and vegetables is their appearance like maturity, colour, shape, aroma, flavour as well as texture. Another important indicator of quality is the absence of harmful substances.

Testing and Monitoring (ITM) program that is made up of the following components:

- Legislative requirements
- Inspection, testing and monitoring schedules
- Maintenance and service records
- Workplace inspections checklists
- Corrective action procedure

Testing and Monitoring Schedules:

Testing and Monitoring Schedule" which identifies what items of equipment need to be tested, the relevant legislation and/or standards that apply to that equipment, and the frequency of testing. The frequency for testing will be determined by:

- The level of risk;
- Relevant legislation
- Manufacturer's recommendation (as per operating manual or other material provided by the manufacturer)

Engineering controls are regularly inspected and tested to ensure their integrity. Engineering controls, including safety devices need to be regularly inspected and tested to ensure their integrity, effectiveness and correct operation. Examples of these types of engineering controls may include the following (not exhaustive):

- Fume cupboards,
- Biosafety cabinets,
- Gas detection systems,
- Machinery guards,
- Emergency stop buttons,
- Local exhaust ventilation
- Pressure relief devices

Most food processors who process fruits and vegetables follow best practices, comply with regulations and also get the fruits and vegetables tested.

Food safety from microbiological contamination:

There are several factors that cause microbiological contamination in fruits and vegetables. Since, food is biological in nature; therefore, it can easily support the growth of pathogens like viruses and bacteria. Fruits and some vegetables are eaten raw food safety needs to be assured. While the fruits and vegetables are being harvested contamination can occur from workers who can transfer pathogens from improper or unsafe handling.

Reusable and unclean storage crates can cause microbiological contamination. Post-harvest, any fruits and vegetables that have a cut are prone to growth of pathogens. Since cut surfaces release liquids that are nutrient rich, pathogens become attached and microbes like bacteria, yeast and fungi that cause spoilage too. Fresh-cut fruits and vegetables can also harbor pathogenic bacteria capable of causing human infections,

Food Safety from chemicals

Fruits and vegetables can get contaminated any time in the food chain from farm to fork, especially chemical contamination. Water pollution, heavy metals in the environment, excessive use of pesticides, and chemical fertilizers can cause chemical contamination.

The main forms of adulteration in fruits and vegetables are addition of non-permitted synthetic colours to alter the appearance, so they look more attractive. The use of non-permitted chemicals to increase shelf life is also rampant.

Processed fruits and vegetable testing in labs

Fruits and vegetables testing in labs to ensure safety and quality for your consumers, authenticity of your business and compliance to regulatory authorities, fruits and vegetables are further processed (e.g. chopped), there is a risk of microorganisms entering the products during the processing steps. Therefore, cleaning and disinfection steps must be regularly checked for their effectiveness.



Figure 2.12: Fruit and vegetable texture analyzer

Measuring the ash content in food is important for a few reasons. Ash content can affect different characteristics of food including physiochemical and nutritional properties.

Ash Determination of food samples is part of the proximate analysis necessary for nutritional evaluation. This ensures the safety of foods, making sure there are no toxic minerals present. The ash content in food can also impact the taste, texture and stability of foods so it is vital to know the mineral content for quality control purposes.

- Processed fruit & vegetable
- Specific gravity
- Sodium chloride
- Total ash
- Acid insoluble ash

- Coloring strength
- Total nitrogen

- Moisture
- Volatile matter
- Total ash
- Acid insoluble ash
- Solubility in cold water
- Bitterness
- Crude fiber
- Coloring matter

2.4 -Investigating problems and implementing corrective action

2.4.1 Investigating problems or inconsistencies in grading outcome to determine cause and corrective actions.

Bruising appears as a result of impacts and compressions of the fruits against other fruits, parts of the trees, containers, and parts of any grading and treatment machinery and on any un cushioned surfaces. Severity of damage to the fruit is primarily related to:

- Height of fall;
- Initial velocity;
- Number of impacts;
- Type of impact surface and size; and
- Physical properties of the fruit, related or not to maturity

Fruits may be classified into different types regarding their most evident physical properties, which are responsible for their susceptibility to bruising. Such a classification is very inaccurate, as many fruits may change from one type to another during ripening or when subjected to different conditions. Nevertheless, some groupings may be made

I. Rigid fruits are those whose strength is based on a mostly rigid structure, surrounded by a thin elastic skin: apples, pears, peaches, nectarines, apricots, avocados, mangoes, papaya, kiwi fruits, potatoes, etc. In this type of commodity resistance is based in the fruit flesh, in its histological and physiological characteristics mainly.

II. Liquid fruits are made up by a liquid or 'soft' mass contained in a mostly elastic skin, their resistance being based on this skin: examples include plums, tomatoes, grapes, cherries and berries.

It is known that many rigid fruits gradually become soft as they mature.

a) Mass of the fruits is crucial in bruising susceptibility, since impact energy is, as known, directly dependent on the dropping mass. Small fruits will be handled much more safely than large fruits.
b) Thick-skinned fruits, like melons, water-melons and bananas are very resistant to impacts, but skin rupture problems may occur with these fruits.
c) Fibrous fruits like pineapples react in a very different manner to impacts, and have not been widely studied.
d) The stone in fruits is the cause of internal bruising for higher-energy impacts in some fruits and varieties.

External damage of the fruit skin can be caused by friction and abrasion against bin walls and conveyors. Oranges are especially susceptible to this type of damage, as are other citrus fruits. Also, some pear varieties are very easily damaged by abrasion. Peeling or 'scuffing' of potatoes and other produce has been studied, and some testing devices exist to measure susceptibility to this type of damage on the skin. Cuts and punctures represent severe damage, caused by inappropriate equipment or handling; they are not related directly to fruit properties, and can be avoided by proper care of the equipment and of the handling systems.

Corrective Action:

I. Retrain any employee found not following the procedures in this SOP.
II. Reject the following:

• Over-ripe or unripe fruit
• Bruised fruit
• Immature fruit

2.5 -Completing documentation and Recording grading specifications for customer

2.5.1 Completing documentation and recording of grading specifications for customer

In the fruit and vegetable market there is a range of quality within any grade and the value of segmentation or of information on quality depends on the dispersion of quality within the grade. The sorting strategy and sorting methods adopted largely determine this. In principle, grades can be used to reduce search costs in several ways. If produce is labeled, buyers can rapidly find the quality they want or, more important, pass by the grades they do not want without even a cursory inspection. Customers can buy on description. Grades can be used for price reporting, so enabling both buyer and seller to make a more informed decision. Even if produce is not labeled, the customers‟ search is reduced just by the knowledge that the product has been sorted to some unknown specifications. A major finding of economic theory is that any change in grading specifications changes all supply and demand functions, for the product, for the grades and for individual items. One cannot use ex ante data, however complete; to describe what will be the effect of introducing a grading scheme throughout a market: any prediction will be a guess. Still less can one predict the effect of introducing a grading system for several competing fruits and vegetables simultaneously.

One can design a grading system that will be better than no grading at all for either most producers or most distributors or most consumers but an enormous effort is necessary to say that one grading system is better than another. In any real market it is very difficult to design a system that will be better for all producers or all distributors or all consumers. It is virtually impossible that a system will benefit all producers, distributors and consumers. There is no theoretical reason to believe a priori that the benefits outweigh the costs.

The Consumer's Choice

There can be no justification for legislation requiring that fruit and vegetables should be labeled at retail unless it can be shown that a significant number of customers do in fact use the information, that it reduces search or risk, or that it makes a significant impact on price or quality. Even if this can be shown, one must ask if different information would not be more helpful.

Customers may treat a good as a search good, examining alternative purchases before deciding which best value is for money.

This is an expensive and time consuming strategy and is normally limited to expensive goods, goods which account for a high proportion of expenditure, goods which have a high risk of being substandard, goods for which the disutility of substandard goods is high and goods which are cheap to inspect. Generally, however, customers buy a product on limited information and evaluate it by consuming it. This is most common for cheap goods, low risk goods and goods that are hard to inspect

Apple fruit characteristics: - Apple will be fine grained, sweet, juicy, mature and good smelling. It should be of normal bloom. Glossy smooth skin, stem intact (if removed broke should be clean) Color of apple will be characteristics of the variety.

Banana fruit characteristics: - Banana will be sweet, aromatic, and firm with starchy fresh and no foreign smell or taste. It will have normal bright bloom with color generally ranging from green, yellow to orange. The size of banana will vary according to variety in the range of 150-250 mm. it will be offered in bunches.

Mango fruit Characteristics: - Mango will be mature, ripe firm, juicy, yield slightly to finger pressure, sweet pleasant aroma.

The color generally ranges from light green to yellow (lemon/golden) to orange as per variety. It is generally available from March to August.

Pine Apple: Fruit Characteristics. Pine Apple will be sweet, firm, juicy, strong sweet aroma and taste, texture not chalky or fibrous

Generally: All fruits fresh will be fresh, ripe, sweet, wholesome, mature, well-formed of good

even size. It will have characteristic color, taste, aroma, shape and visual appearance, as applicable to each fruit fresh and its varieties. The fruit fresh should mature naturally on trees or under normal storage conditions. It will be practically free from insects and pests infestation and totally free from fungal or bacterial rot. It will also be free from signs of improper storage, handling and transportation.

Propose here merely to state as clearly as possible the aims as they can be derived from various public and private statements these are the aims.

A. To reduce the price to the consumer

- Improved information means less search and risk for the consumer and so, in effect, a lower price. If all produce in shops is labeled, search will be reduced.
- Improved sorting will mean that there is less variation within a display, enabling the consumer to find her optimum choice with less search cost, for instance by enabling her to ask the retailer for 1 kg of tomatoes instead of having to select the tomatoes one by one.
- Reducing risk and search by forbidding the sale of any produce that has more than a certain percentage that does not meet a certain minimum standard.
- Reducing the confusion that arises when there are several parallel grading systems and a multiplicity of brands.
- The grading system will allocate supplies more efficiently, so that different segments of the market get the grades they prefer, and as a result consumer surplus is increased.
- The EEC grading system will stabilize supplies by selective use of minimum standards legislation and so increase consumer surplus.
- Reducing distribution costs and so reducing retail price

B. To improve the quality bought by the consumer

- Preventing the sale of any product that does not meet certain minimum standards.
- Allocating the supplies more efficiently so different segments get the quality they prefer.

- Ensuring that the product is sorted so a more uniform and, by implication, better product is offered to the consumer.

C. Increasing Distributors' Profits

- Reducing retailers‟ procurement costs
  - ✓ by permitting buying on description
  - ✓ By improving price reporting
  - ✓ By reducing the necessity for inspection.
- Permitting more accurate segmentation, with each retailer buying only the quality he wants.
- Reducing waste, as the retailer buys only the quality he wants (i.e. only a limited proportion is out of grade).
- Reducing the display space and floor space required as search time is reduced and each customer spends less time in the fruit and vegetable department.
- Permitting the retailer (or wholesaler) to get the profits of segmentation by selling each group of customers (Or shops.) Only the qualities they require.
- Reducing supply by minimum standards and so increasing the price charged, (but also the price they pay).
- Reducing fluctuations in supply by selective use of minimum standards legislation and so reducing handling costs and the price fluctuations that upset customers.

D. Increasing producers' profits

- Reducing supply by minimum standards will increase the average price and possibly the return.
- Improved segmentation will increase the total return.
- Improved price reporting will permit more efficient selling and, therefore, higher prices.
- Preventing retailers from mixing two grades together. This is frequently stated as an aim of the system. I am unable to see why; nor have I ever seen retailers mixing grades; I have no reason to believe that it would

Self-Check 2	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers

Test I: Choose the best answer among the given alternative

1. When setting grading parameters for fresh produce, which of the following is a common grading criterion?
   a) Weight
   b) Taste
   c) Packaging
   d) Shelf life

2. What is the purpose of defining a grading scale?

   a) To determine the market price of the produce

   b) To assign unique identification codes to each produce item

   c) To establish different grades or quality levels for the produce

   d) To calculate the nutritional value of the produce

3. What are thresholds used for in the grading process?

   a) To determine the ripeness of the produce

   b) To identify the source of the produce

   c) To set the acceptable ranges or limits for each grading criterion

   d) To track the location of the produce within the supply chain

4. Why is it important to conduct test runs and calibration after entering grading parameters?

   a) To determine the nutritional value of the produce

b) To assess the market demand for the produce

c) To verify the accuracy and reliability of the grading parameters

d) To evaluate the impact of grading on the shelf life of the produce

5. What is the role of monitoring and fine-tuning in the grading process?

a) To determine the optimal cooking methods for the produce

b) To calculate the average yield of the produce

c) To continuously evaluate and adjust the grading parameters based on actual results and feedback

d) To identify the potential allergens in the produce

6. When setting grading parameters, which of the following is NOT a common grading criterion for fresh produce?
a) Size
b) Color
c) Taste
d) Shape

7. What is the purpose of entering specifications into a computer for grading fresh produce?
a) To determine the market value of the produce
b) To automate the grading process
c) To prevent contamination of the produce
d) To calculate the nutritional content of the produce

8. How are thresholds used in the grading process?
a) To determine the weight of the produce
b) To identify the source of the produce
c) To set the acceptable ranges or limits for each grading criterion
d) To determine the ripeness of the produce

9. Why is it important to conduct test runs and calibration after entering grading parameters?
a) To ensure the produce is free from pesticides
b) To calculate the yield of the produce
c) To verify the accuracy and reliability of the grading parameters

d) To assess the market demand for the produce

10. How does monitoring and fine-tuning of grading parameters contribute to the grading process?
    a) It determines the shelf life of the produce
    b) It identifies the countries of origin for the produce
    c) It ensures the produce is organic
    d) It allows for adjustments to optimize grading accuracy and efficiency

Test II: Write true if the statement is correct and false if the statement is incorrect

1. Grading parameters are set to ensure consistent and reliable grading of fresh produce.
2. The grading scale represents different grades or quality levels for the produce.
3. Thresholds are used to determine the acceptable ranges or limits for each grading criterion.
4. Test runs and calibration are necessary to validate the accuracy of the grading parameters.
5. Thresholds are used to determine the maximum quality level for each grading criterion.
6. Test runs and calibration are not necessary after entering grading parameters.
7. Monitoring and fine-tuning of grading parameters are not important for optimizing grading performance.

Test III: Write short answer for the following question.

1. What is the purpose of entering specifications into a computer for grading fresh produce?
2. Why is it important to define a grading scale when setting grading parameters?
3. What role do thresholds play in the grading process?
4. Why is it necessary to conduct test runs and calibration after entering grading parameters?
5. How does monitoring and fine-tuning contribute to the optimization of grading performance?

Operation Sheet 2

2.1 The procedure for entering specifications into a computer to set grading parameters

Objective:

The objective of this procedure is to accurately enter specifications into the computer system to set grading parameters.

A. Tools and equipment's

- Computer System
- Grading Software
- User Manual or Documentation
- Representative Samples of Fresh Produce
- Measuring Tools (scales, calipers, rulers, colorimeters, or other instruments)
- Reference Materials
- Workspace and Safety Equipment
- Data Storage and Backup

B. Procedure of entering specification to set grading parameters

- Launch the grading software on the computer or terminal connected to the grading equipment.
- Log in to the grading software using your credentials or access privileges.
- Choose the specific type of fresh produce you wish to set grading parameters for.
- Identify the grading criteria or characteristics that need to be considered for the selected produce type.
- Determine the grading scale or range for each grading criterion
- Establish the threshold values for each grading criterion.
- Conduct test runs with representative samples of fresh produce to verify that the grading parameters are functioning as intended.

- Continuously monitor the grading process and review the graded output.

LAP TEST-2	Performance Test

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

Task 1: Enter specifications into a computer to set grading parameters for fresh produce.

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2. *Fresh Produce Consortium (FPC) URL: https://www.freshproduce.org.uk/*
3. *Produce Marketing Association (PMA)URL: https://www.pma.com/*
4. *European Fruit and Vegetable Association (Freshfel Europe) URL: https://www.freshfel.org/*
5. *World Agri-Tech Innovation Summit URL: https://worldagritechinnovation.com/*
6. *Canadian Food Inspection Agency (CFIA) URL: https://www.inspection.gc.ca/*
7. *Website: Food and Agriculture Organization of the United Nations (FAO) URL: http://www.fao.org/*

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