Post-Harvest and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

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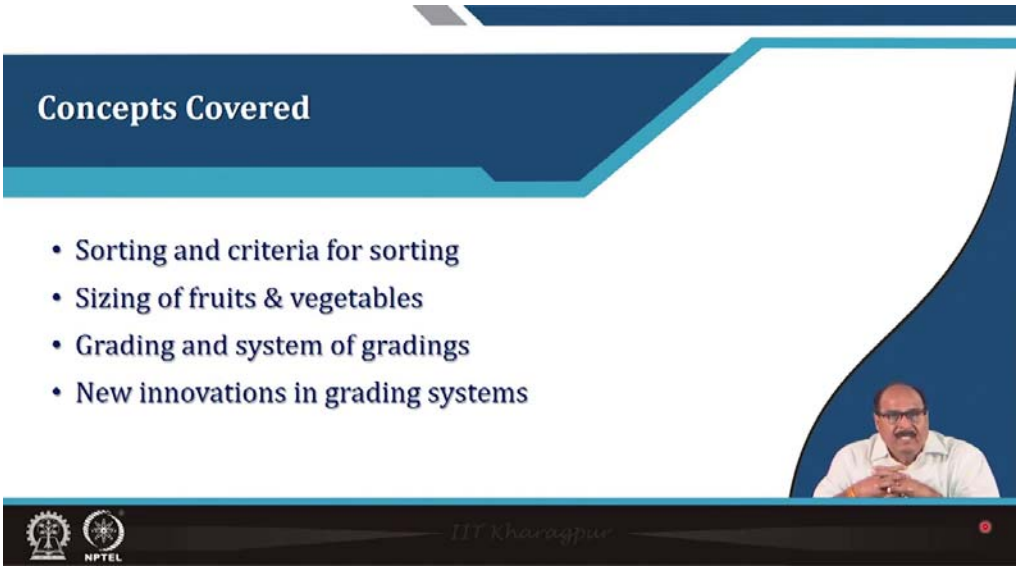
Lecture 17
Sorting and Grading

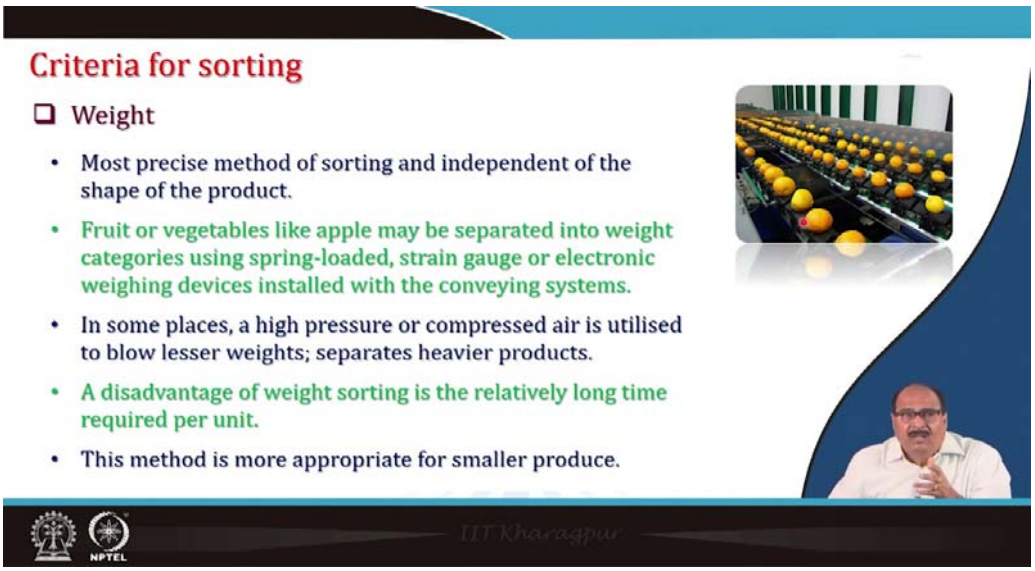


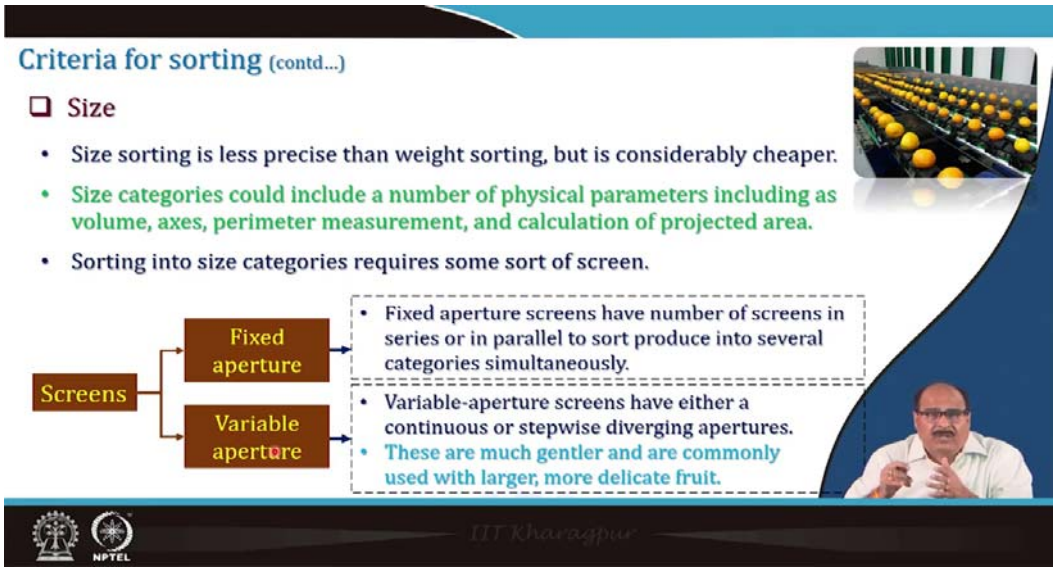
This lecture covers various concepts related to sorting and criteria for sorting, sizing of fruits and vegetables, grading and systems of grading and new innovations in grading systems.

Sorting

Sorting refers to the separation of foods into categories based on a measurable physical property such as size, shape, weight, and colour.

The purpose of sorting is to remove items, which are undersized, oversize or under ripe, misshapen and damaged. To meet requirements of a grade established by the centre, state or marketing agreement authority. To improve attractiveness of the produce and reduce the quantity to be handled during subsequent operations like grading, packaging, etc. To remove the damaged produce which reduce losses due to post harvest diseases during transport and storage.



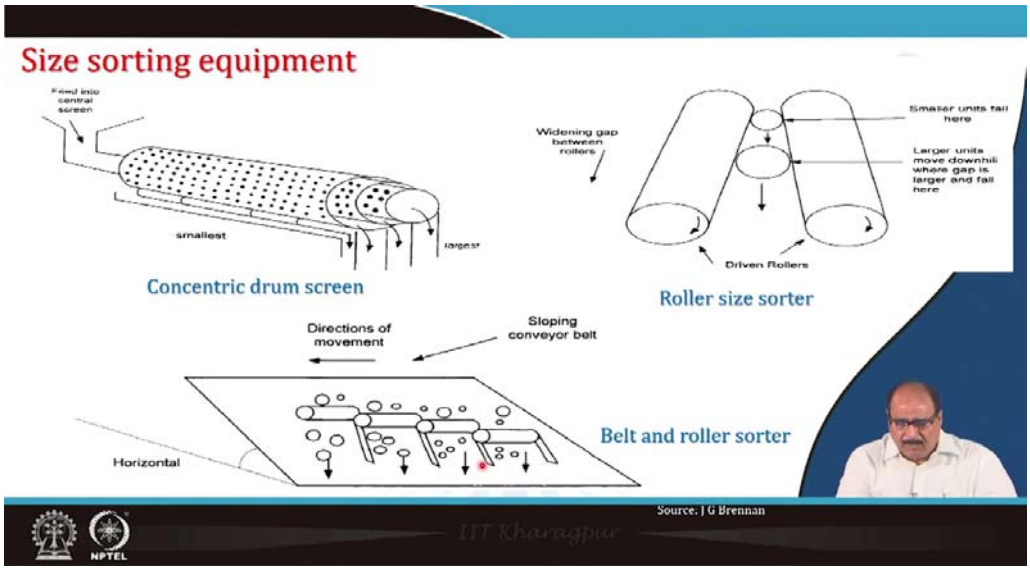


Criteria for sorting

On the basis of weight: It is the most precise method of sorting and independent of the shape of the product. Fruits or vegetables like apple may be separated into weight categories using spring-loaded strain gauge or electronic weighing devices installed with the conveyor system or conveying system. In some places, a high pressure or compressed air is utilized to blow lesser weights and it separates heavier products. A disadvantage of weight sorting is the relatively long time required per unit. This method is more appropriate for the smaller produce.

On the basis of size: Size sorting is less precise than the weight sorting but it is considerably cheaper. Size categories could include a number of physical parameters including as volume, axes, perimeter measurement, and calculation of projected area. Sorting into size categories requires some sort of screen. This screens may have a fixed or variable aperture.

Fixed aperture screens have number of screen in series or in parallel to sort produce into several categories simultaneously. Whereas the variable aperture screens, they have either a continuous or step-wise diverging aperture. These are much gentler and are commonly used with large or more delicate fruits.

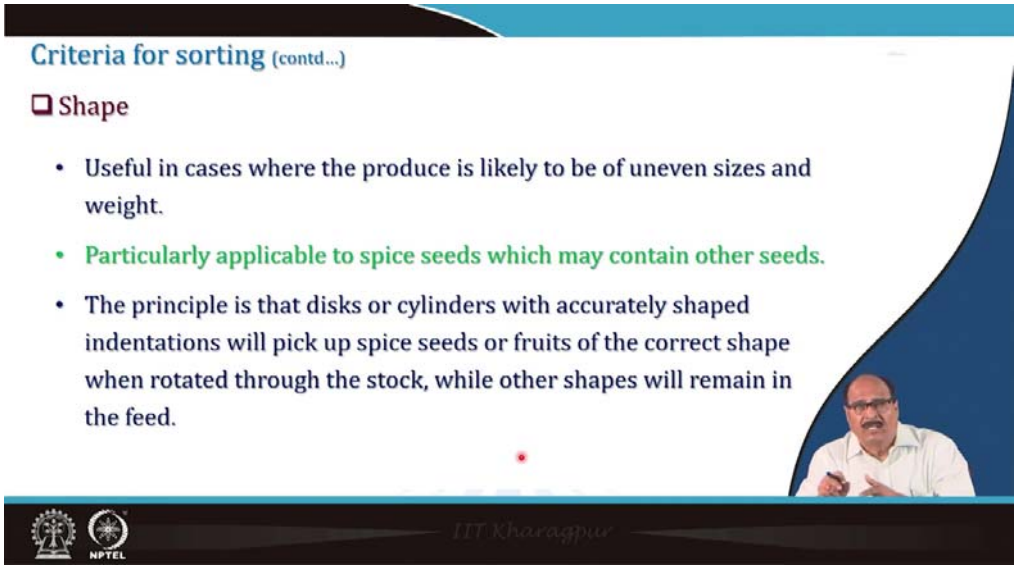


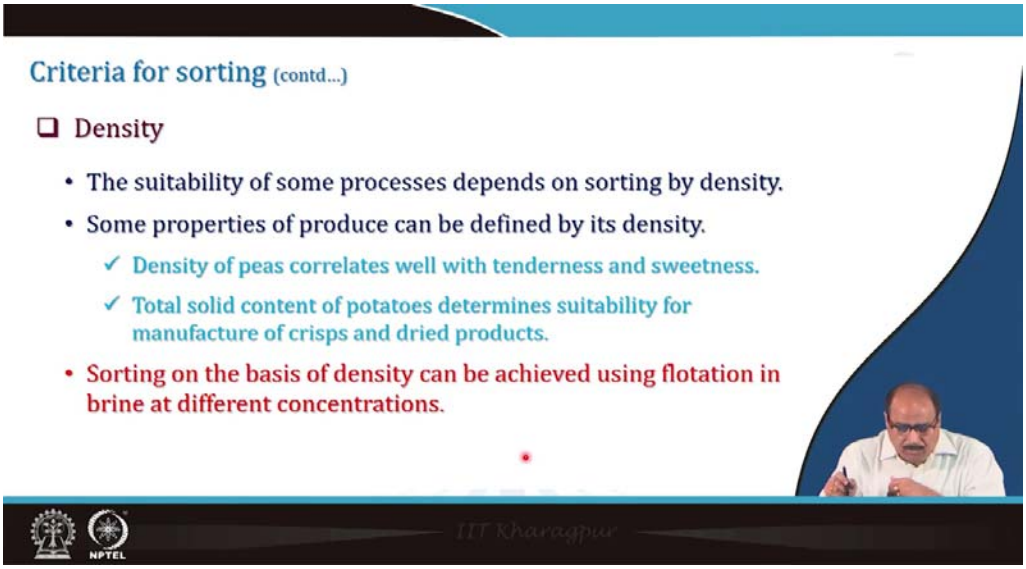
Size sorting equipment

In concentric drum screen, the fruits or vegetable is fed into the central screen. It moves in various holes with different sizes. When it moves the smaller, medium, and large sized particles are grouped.

Roller size sorter has rollers with a widening gap between the rollers to separate the materials moving in the gaps based on various sizes.

In **belt and roller sorter,** a sloping conveyor belt is used where different sized materials are grouped.



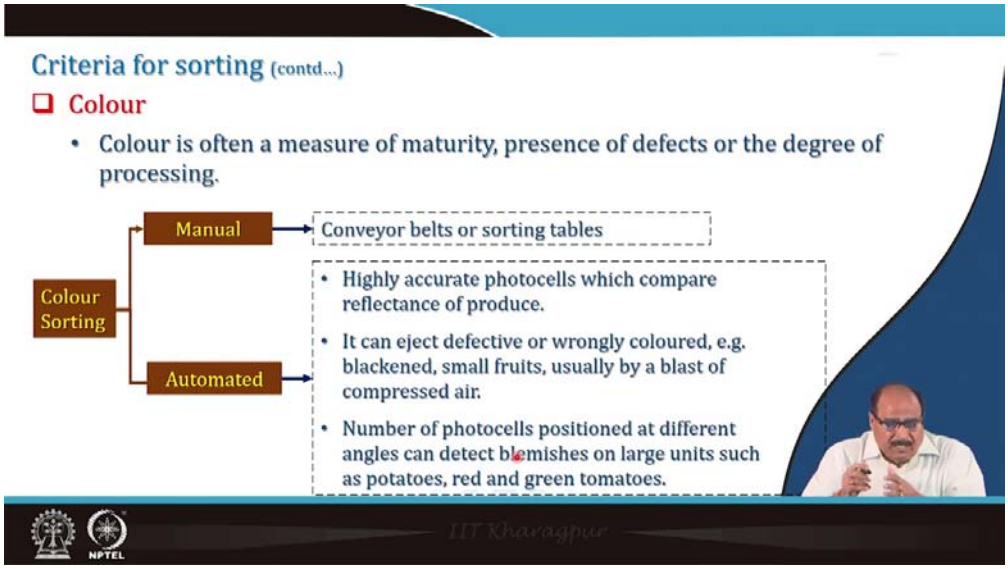


Criteria for sorting

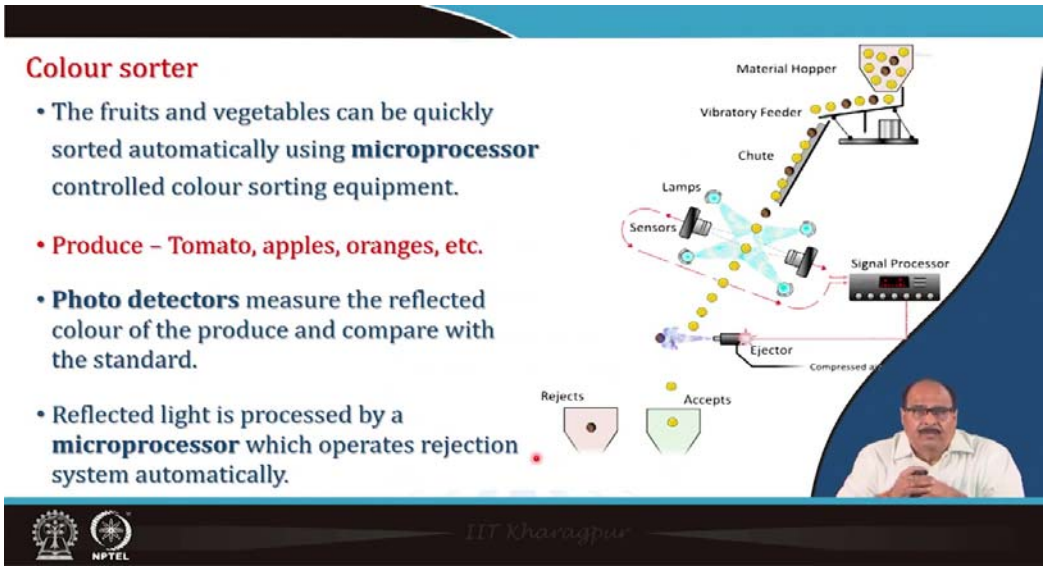
Shape: Useful in cases where the produce is likely to be of uneven sizes and weight. Particularly applicable to spice seeds which may contain other seeds. The principle is that disks or cylinders with accurately shaped indentations will pick up spice seeds or fruits of the correct shape when rotated through the stock, while other shapes will remain in the feed.

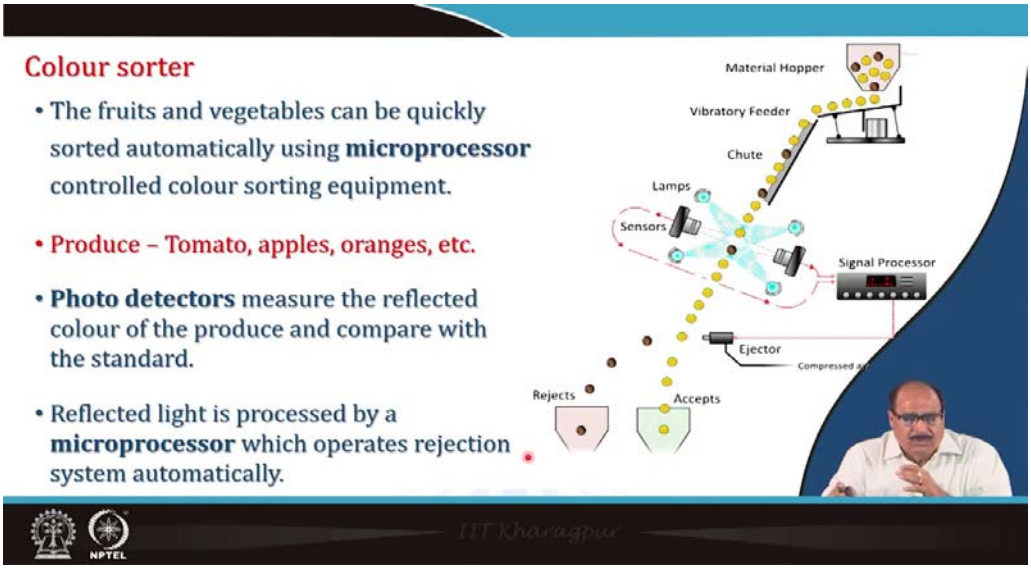
Density: The suitability of some processes depends on sorting by density. Some properties of produce can be defined by its density. For instance, density of peas correlates well with tenderness and sweetness. Total solid content of potatoes determines suitability for manufacture

of crisps and dried products. Sorting on the basis of density can be achieved using flotation in brine at different concentrations.



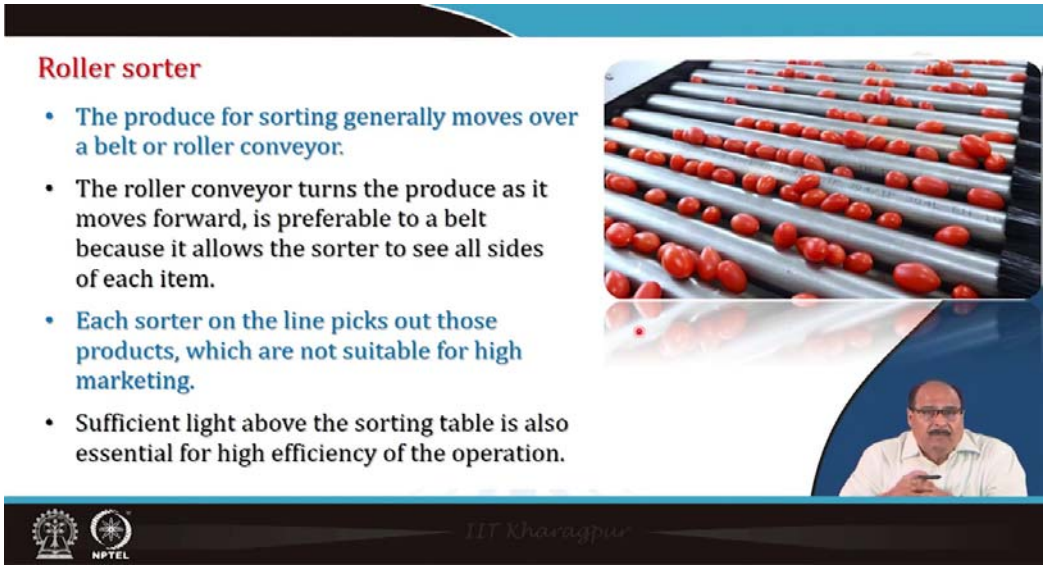
Colour: It is the measure of maturity, presence of defects or degree of processing. Colour sorting it can be done manually or by automated system. Conveyor belts or sorting tables are used for manual sorting. But in the automated system highly accurate photocells are used which compare the reflectance of the produce. It can eject defective or wrongly coloured material. For example, blackened or small fruits are removed by a blast of compressed air. The number of photocells are positioned at different angles in the system, which can detect blemishes on large units such as potatoes, red and green tomatoes.





Colour sorter

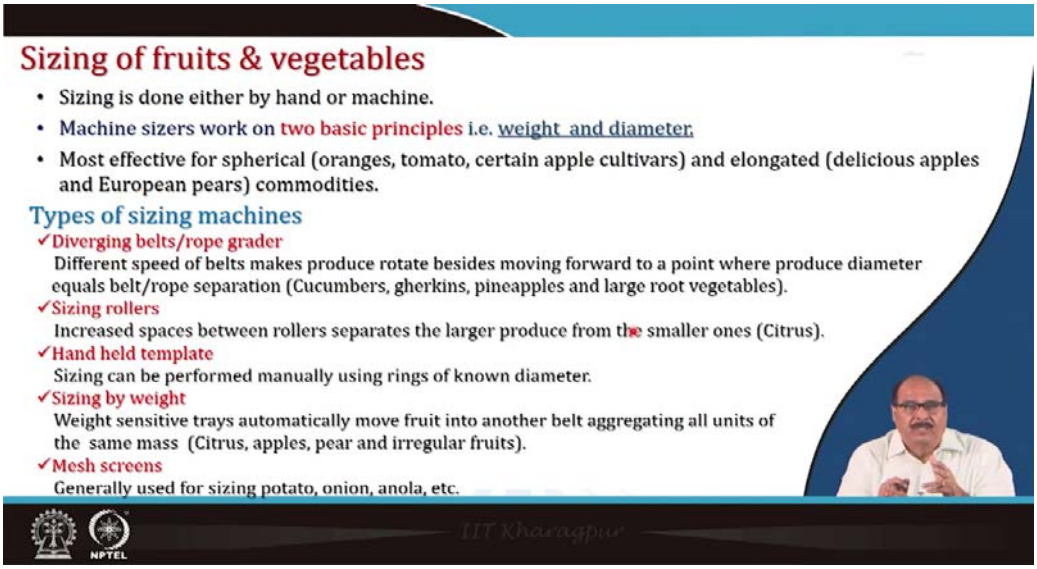
The fruits and vegetables like tomato, apples, oranges can be quickly sorted automatically using microprocessor control colour sorting equipment. Photo detectors measure the reflected colour of the produce and compare it with the standard. The sensors they sense these colours of the different commodity, this signal is sent to the data processor unit and which finally, analyses and send its output to the ejector. Reflected light is processed by a microprocessor which operates rejection system automatically.



Rollers sorter

The produce for sorting generally moves over a belt or a roller conveyor. The roller conveyor turns the produces as it moves forward, is preferable to a belt, because it allows the sorter to see

all sides of each item. Each sorter on the line picks out those products, which are not suitable for high marketing. Sufficient light above the sorting table is also essential for high efficiency of this operation.

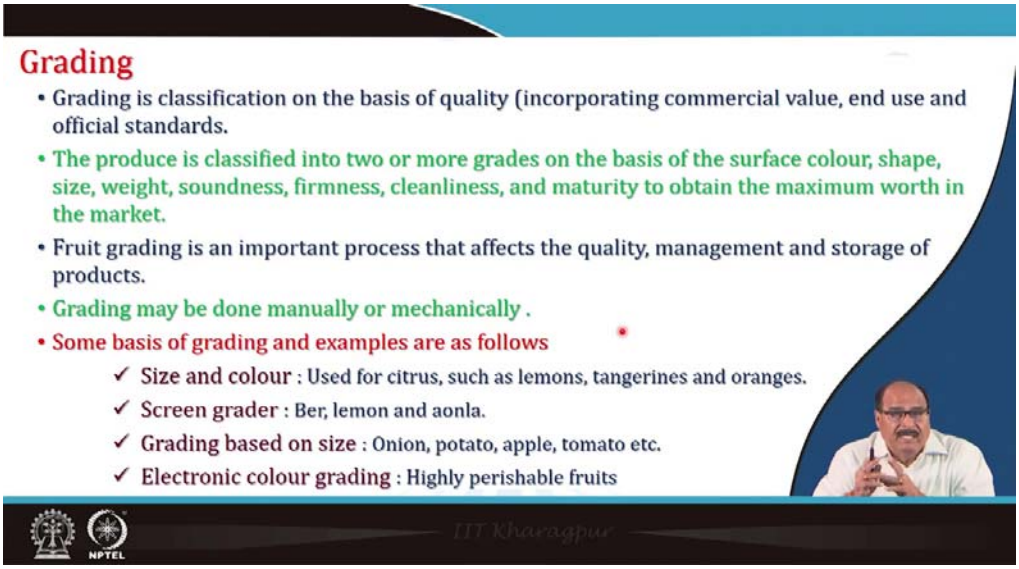


Sizing of the fruits or vegetables

Sizing is done either by hand or by machine. The machine sizers work on two basic principles, i.e. weight and diameter. Most effective for spherical commodities like oranges, tomatoes, certain apple cultivars and elongated commodities like delicious apple and European pears.

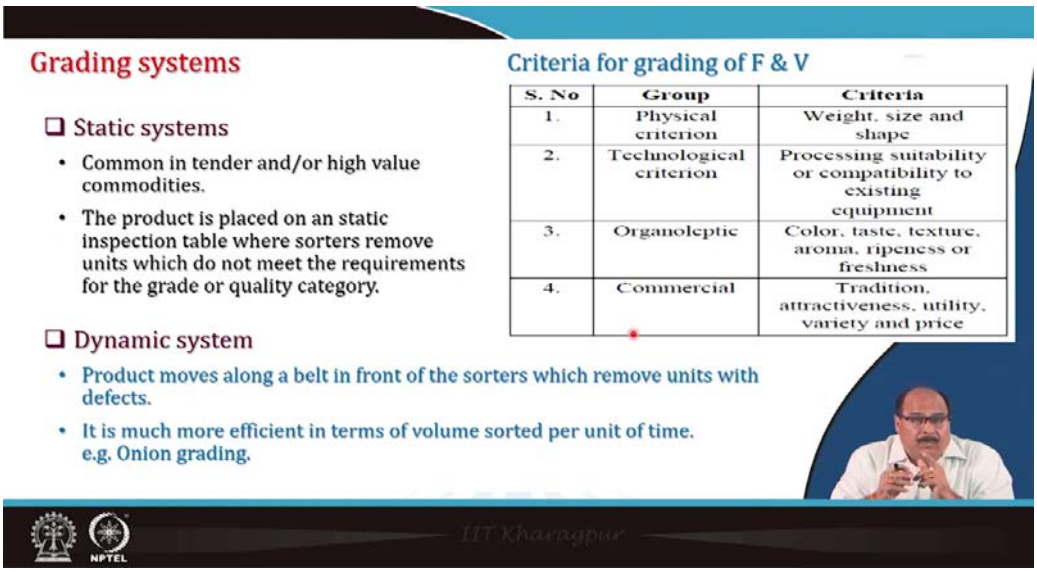
Type of sizing machines

- ***Diverging belt or rope graders***: Different speed of belts makes produce rotate besides moving forward to a point where produce diameter equals belt/rope separation (Cucumbers, gherkins, pineapples and large root vegetables).
- ***Sizing rollers:*** It has increased spaces between the rollers that separates longer produce from the smaller ones, it is suitable for the citrus fruits.
- ***Hand held template***: Sizing can be performed manually using rings of known diameter.
- ***Sizing by weight***: Weight sensitive trays automatically move fruit into another belt aggregating all units of the same mass such as citrus, apples, pears are irregular fruits.
- ***Mesh screens***: Generally used for sizing potato, onion, aonla et cetera.



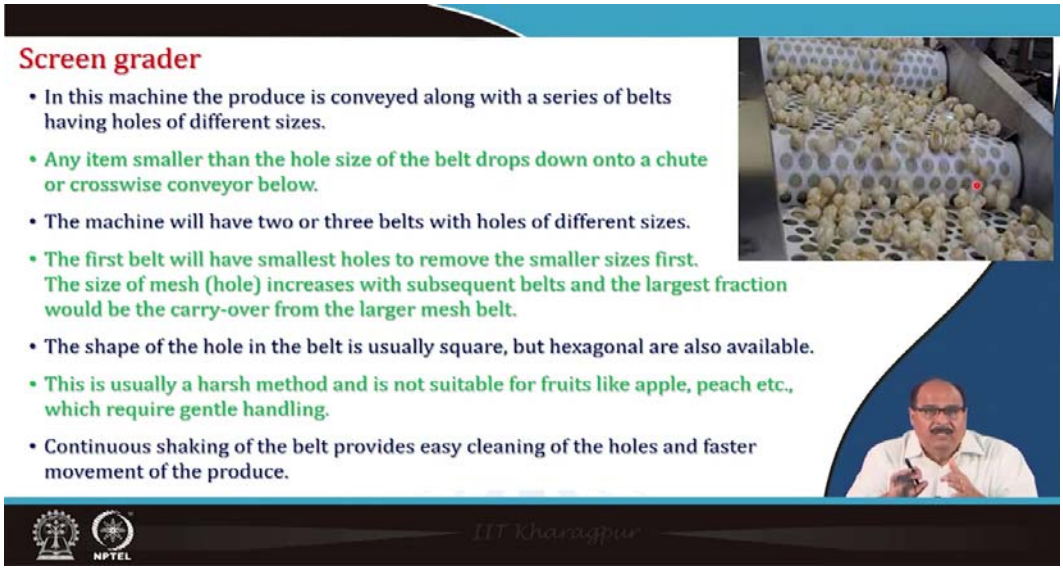
Grading

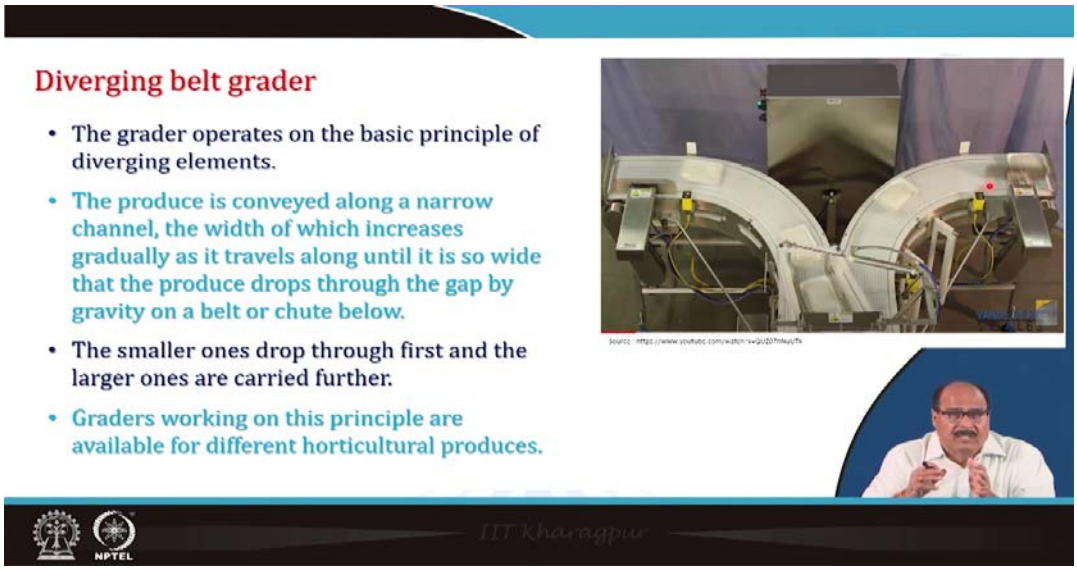
Grading is a classification on the basis of the quality. The main difference between sorting and grading is in grading the commodities are classified on the basis of the quality whereas the sizing or sorting is classification on the basis of their physical properties. The produce is classified into two or more grades on the basis of the surface colour, shape, size, weight, soundness, firmness, cleanliness, and maturity to obtain the maximum worth in the market. Fruit grading is an important process that affects the quality management and storage of the produce. Grading may be done manually or mechanically. Some basis of the grading and examples are: Size and colour grading used for citrus foods such as lemons, tangerine and orange, Screen graders are used for ber, lemon, anola, Grading based on size is used for onions, potato, apple tomato, and electronic colour grading is used for highly perishable fruits.



Grading system

They maybe as static system or dynamic system. Static system is common in tender and high value commodities. The product is placed on a static inspection table where sorters removed the units which do not match the requirements for the grade or the quality category. Whereas in the dynamic system product moves along a belt in front of the sorters which remove units with defect. It is much more efficient in terms of volume sorted per unit time. For example, in onion grading et cetera dynamic system has proven to be much effective (Eg. Onion). The criteria for grading of fruits and vegetables may be in terms of physical, technological, organoleptic, and commercial criterion.



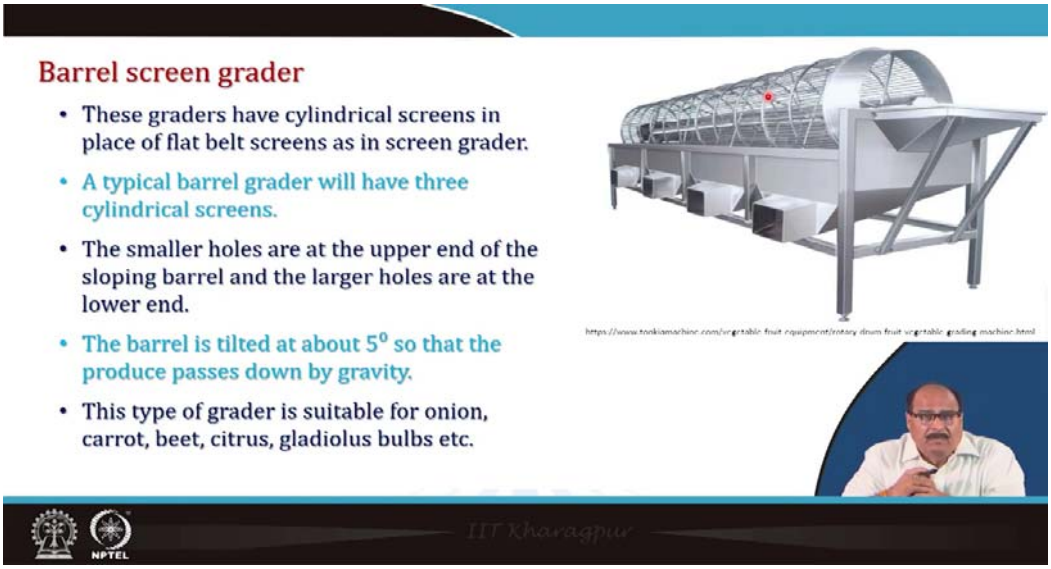


Screen grader

In this machine the produce is conveyed along with a series of belt having holes of different sizes. Any item smaller than the hole size of the belt drops down onto a chute or crosswise conveyors below. The machine will have two or three belts with the holes of different sizes. The first belt will have smallest holes to remove the smaller size first. The size of the mess increases with the subsequent belts and the largest fraction would be the carry-over from the larger mesh belt. The shape of the hole in the belt is usually square but hexagonal shapes are also now available. This is usually a harsh method and is not suitable for fruit like apple, peach which require gentle handling. Continuous shaking of the belt provides easy cleaning of the holes and faster movement of the produce.

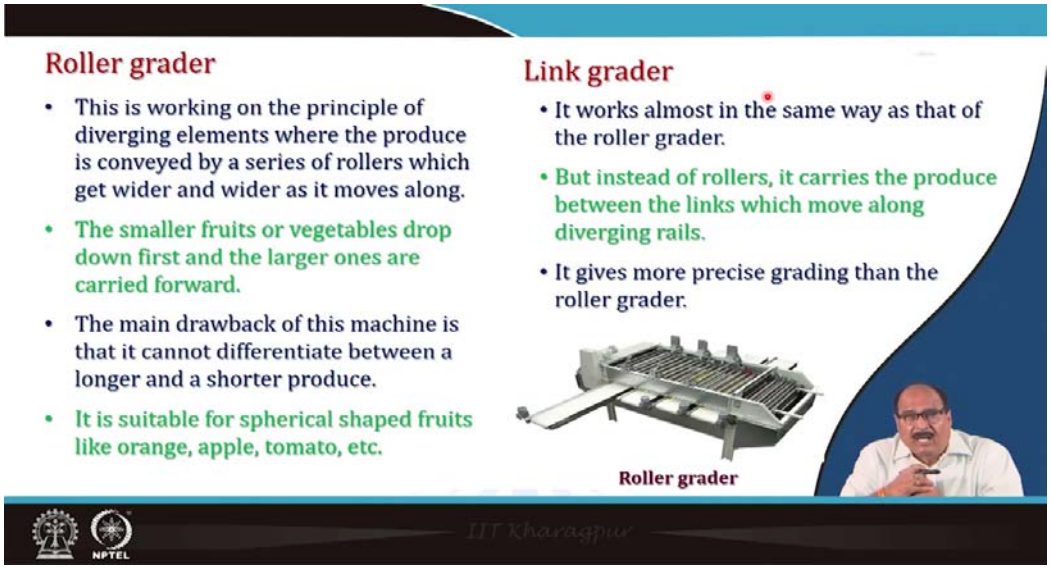
Diverging belt grader

The grader operates on the basic principle of diverging elements. The produce is conveyed along a narrow channel, the width of which increases gradually as it travels along until it is so wide that the produce drops through the gap by gravity and a belt or chute below. The smaller ones drop through first and the larger ones are carried further. Graders working on this principle are available for different horticultural produces.



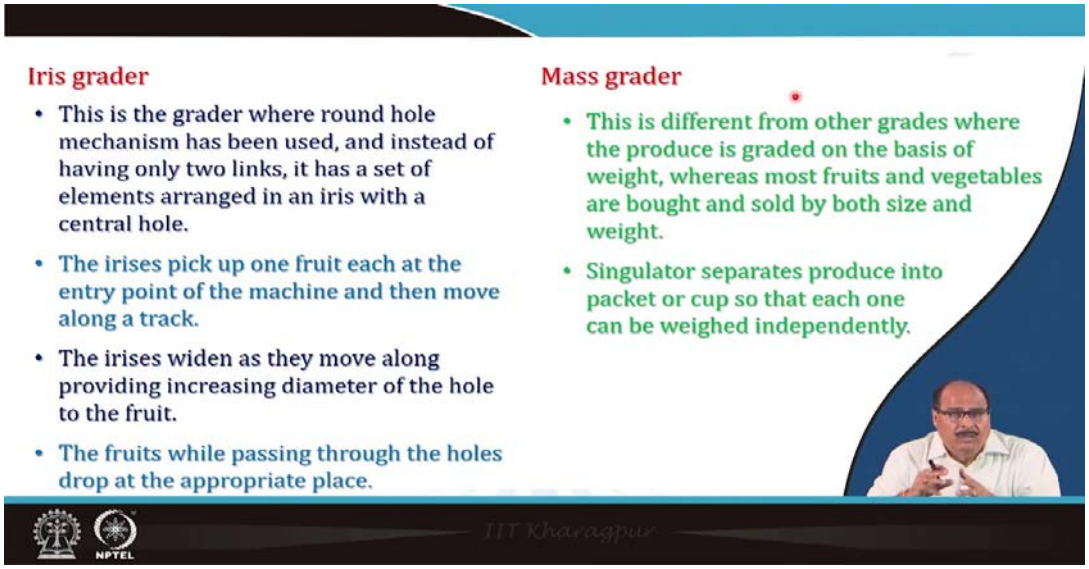
Barrel screen graders

These graders have cylindrical screens in place of flat belt screen as in screening grader. A typical barrel grader will have three cylindrical screens. The smallest holes are at the upper end of the sloping barrel and the largest hole are at the lower end of the sloping barrel. The barrel is tilted at around 5° so that the produce passes down by gravity. This type of grader is suitable for onion, carrot, beet, citrus, gladiolus, and bulbs.



Roller graders works on the principle of diverging elements where the produce is conveyed by a series of rollers which get wider as it moves along. The smaller fruits or vegetables drop down first and the larger ones are carried forward. The main drawback of this machine is that it cannot differentiate between the longer and shorter produce. It is suitable for a spherical shape fruits like oranges, apples, and tomato.

Link grader works almost in the same way at that of roller grader. But instead of rollers, it carries the produce between the links which moves along the diverging rails. It gives more precise grading than the roller grader.

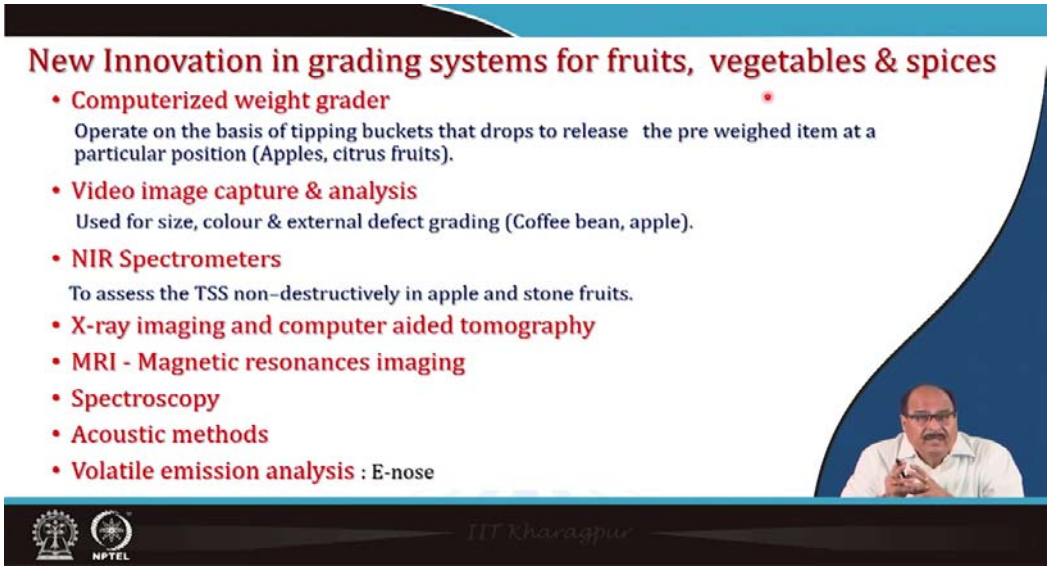


Iris grader

This is the grader where round hole mechanism has been used, and instead of having only two links, it has a set of elements arranged in an iris with a central hole. The iris picks up on fruit each at the entry point and then moves along a track. The irises widen as they move along providing increasing diameter of the hole of the fruit. The fruit while passing through the holes drops at appropriate place.

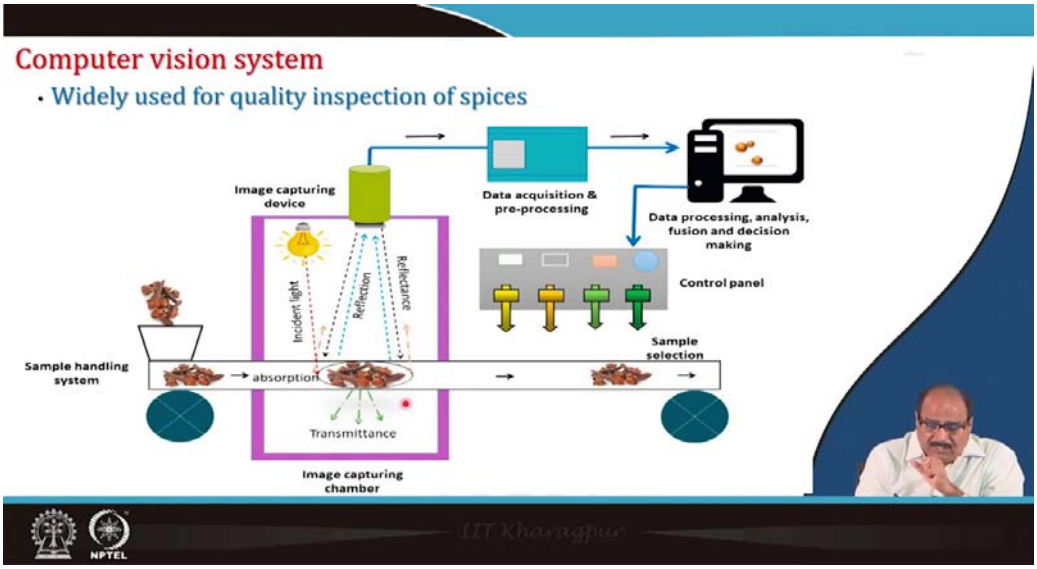
Mass grader

It is different from the other grader where the produce is graded on the basis of the weight, whereas most of fruit and vegetable are brought and sold by both the size and weight. Singulator separates produce into the packet or cup so that each one can be weighed independently.



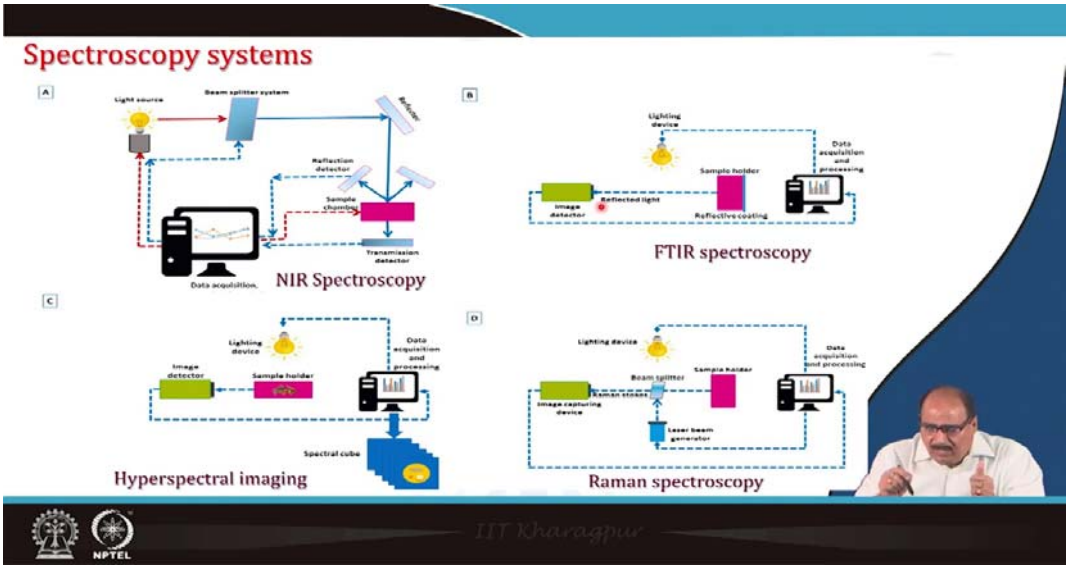
New innovation in grading system for fruits, vegetables and spices

- ***Computer weight grader*** operates on the basis of tipping buckets that drops to release the pre-weight item at a particular position (Eg. apple, citrus fruits).
- ***Video image capture and analysis systems*** used for size, colour and external defect grading (Eg. coffee bean, apple).
- ***NIR spectrometer*** is used to assess the TSS non-destructively in apple and stone fruits.
- ***X-ray imaging and computer aided tomography***
- ***Magnetic resonance imaging***
- ***Spectroscopy***
- ***Acoustic methods or volatile emission analysis like E-nose or E-tongue are now becoming more popular.***



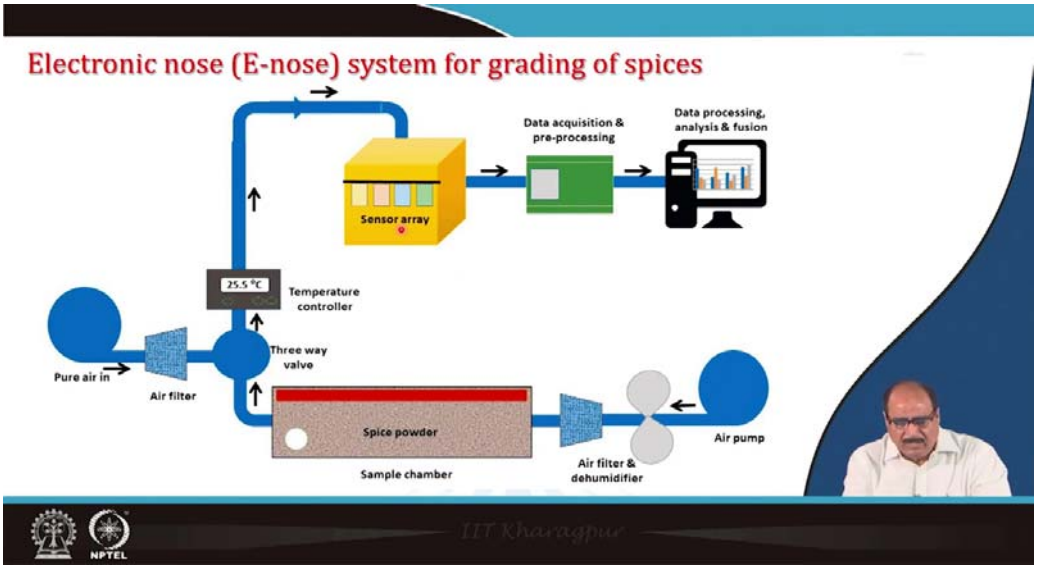
Computer vision system

It is widely used for quality inspection of spices. It can also be used to inspect the quality of fruits, vegetables or any other commodity. There is an image capturing chamber where the sample moved through a conveying system comes across the light source. The light falls on the product and some of the light is reflected back. Then the reflected light is captured in the image capturing device. It sends the data to the data acquisition and pre-processing system where the data is processed and send to the control system.



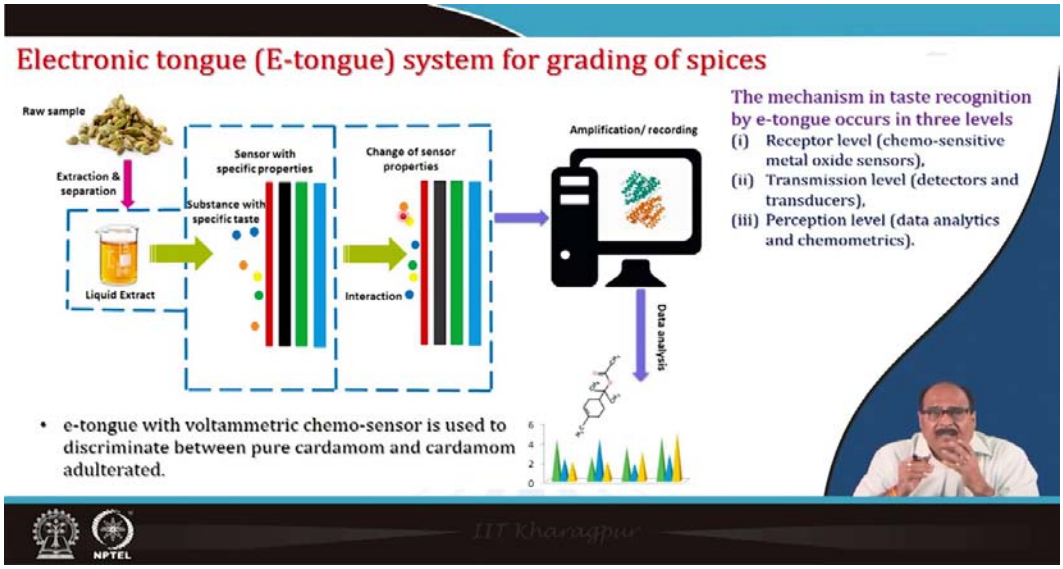
Spectroscopy systems

Some of the spectroscopy systems are NIR spectroscopy, FTIR spectroscopy, Raman spectroscopy, and Hyperspectral imaging.



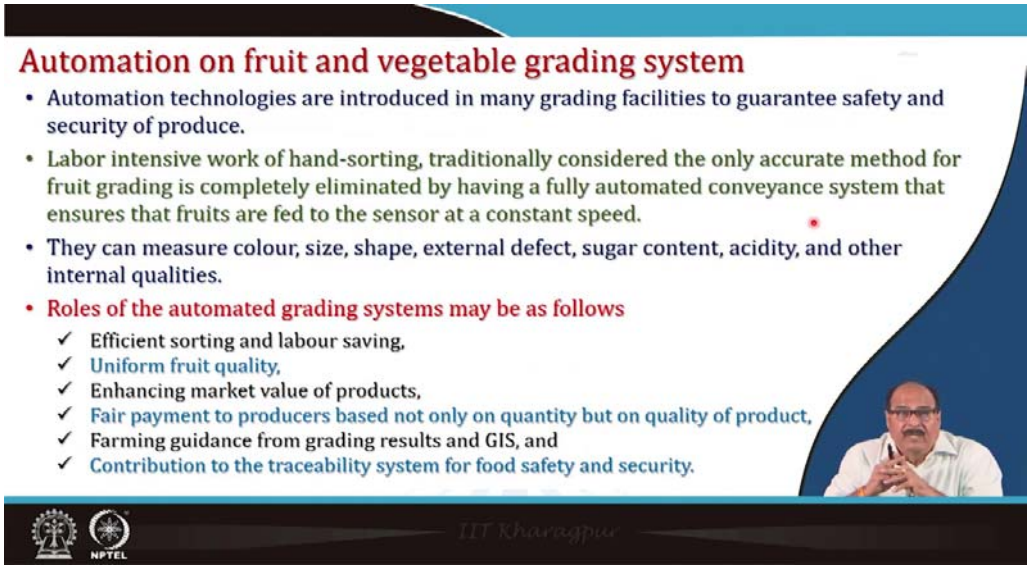
Electronic nose (E-nose) system for grading of spices

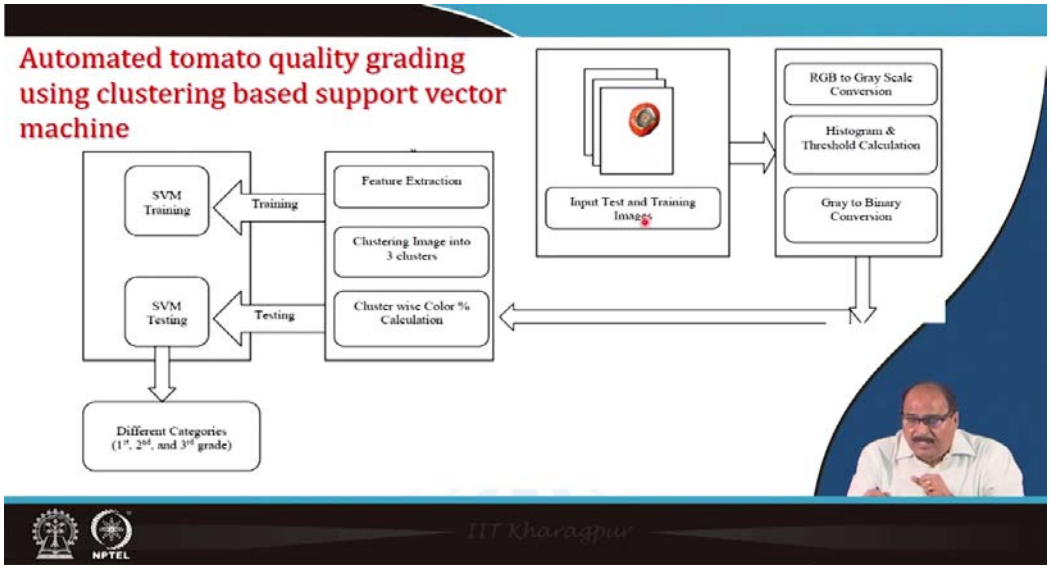
There are various sensors in the sensor arrays which mimics human olfactory. Similarly, some metal oxide sensors are there. The commodity is kept in the sample chamber. Air is pumped through air pump and passed through air filter and dehumidifier. As the aromatics, and the flavours are volatile components, they volatilize and pass through the three-way valve to heat up to desired level (i.e. temperature controller) followed by the sensor arrays. These volatile compounds are sensed while the data is acquired and pre-processed. Finally, data analysis by comparing the data with the library set and fusion is done through different softwares.



Electronic tongue (E-tongue) system for grading of spices

Electronic tongue works like our taste buds available on the tongue. E-tongue with voltammetric chemo-sensor is used to discriminate between pure cardamom and cardamom adulterated. The liquid extract from pure cardamom is taken and then this extract is sent to the sensor. It senses the compounds in it and the data is analysed by storing into its memory. Thus, on exposing the system to the extracted liquid of the adulterated one, it compares with the stored library and discriminates the commodity. The mechanism in the taste recognition by E-tongue occurs in three levels, (1) At the receptor level: chemo-sensitive metal oxide sensor, (2) At transmission level: detectors and transducers, (3) At the perception level: data analytics and chemometrics.

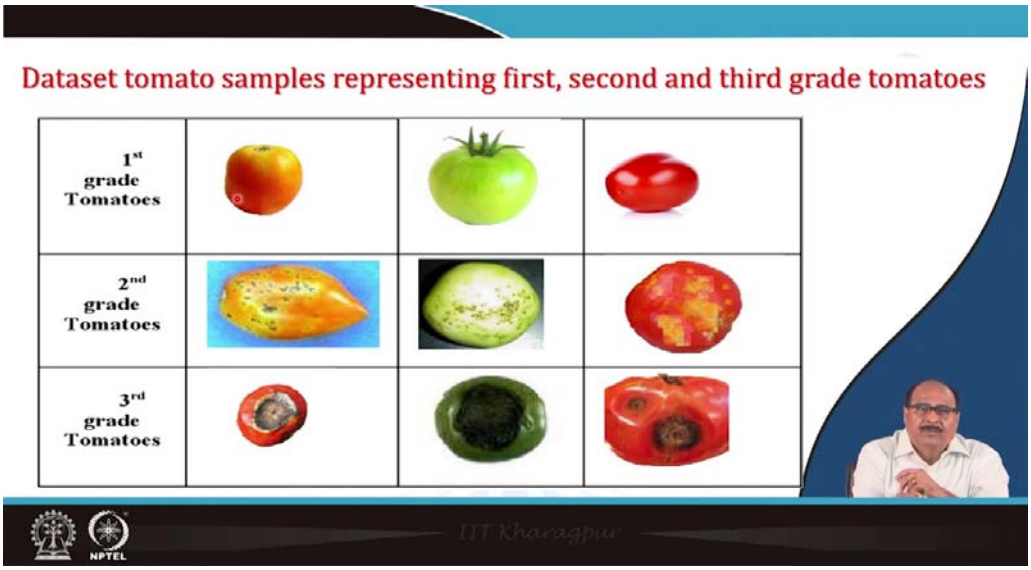




Automation of fruits and vegetable grading system

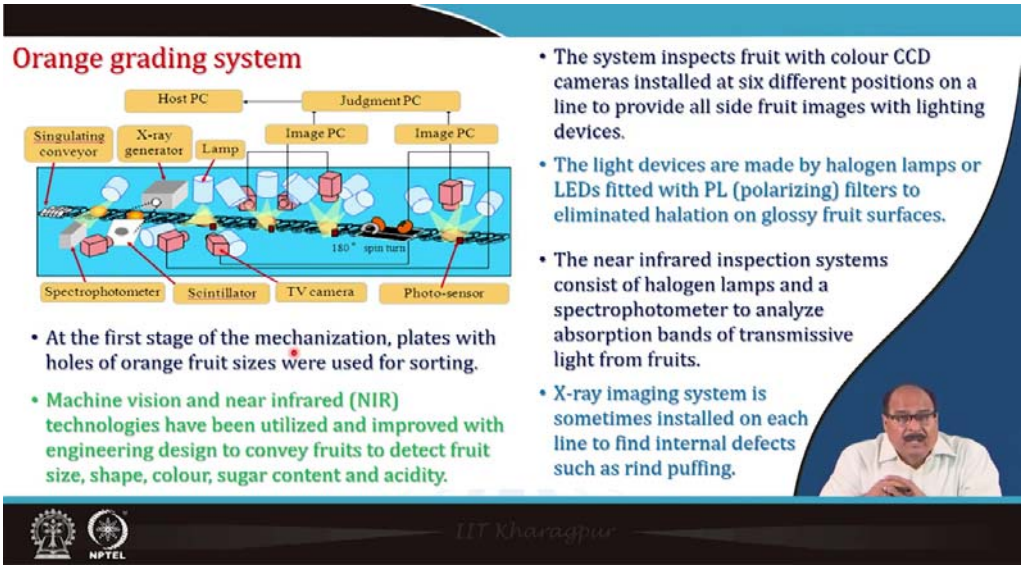
Automation technologies are introduced in many grading facilities to guarantee safety and security of produce. Labor intensive work of hand-sorting, traditionally considered the only accurate method for fruit grading is completely eliminated by having a fully automated conveyance system that ensures that fruits are fed to the sensor at a constant speed. They can measure colour, size, shape, external defect, sugar content, acidity, and other internal qualities. Roles of the automated grading systems may be as follows, (1) Efficient sorting and labour saving, (2) Uniform fruit quality, (3) Enhancing market value of products, (4) Fair payment to producers based not only on quantity but on quality of product, (5) Farming guidance from grading results and GIS, and (6) Contribution to the traceability system for food safety and security.

The schematic figure shows automatic tomato quality grading using clustering-based support vector machine. The input test and training images are processed by converting them from RGB to grey scale and histogram and threshold is calculated followed by grey scale conversion to binary version. The data set is then divided into support vector machine (SVM) testing and training sets by considering different features categorised into various clusters. This helps in separating any tomato commodity into different categories such as first, second, and third grade.



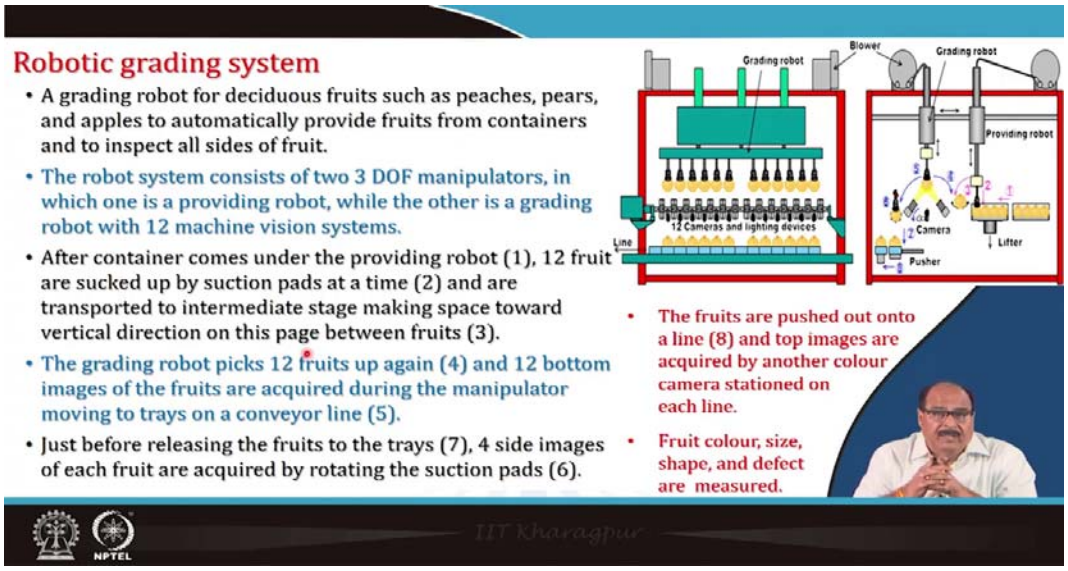
Dataset tomato samples representing the first second and third grade tomatoes

First grade represents pure green or medium ripe or fully ripe. But in second grade and third grade, it detects the tomatoes that are spoiled or about to spoil.



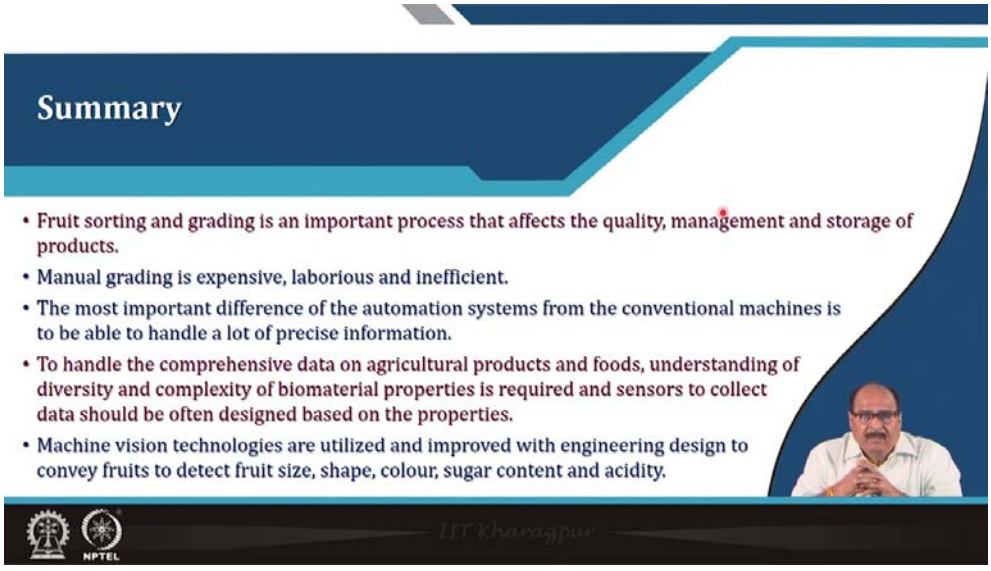
Orange grading system

At the first stage of the mechanization, plates with holes of orange fruit sizes were used for sorting. Machine vision and near infrared (NIR) technologies have been utilized and improved with engineering design to convey fruits to detect fruit size, shape, colour, sugar content and acidity. The system inspects fruit with colour CCD cameras installed at six different positions on a line to provide all side fruit images with lighting devices. The light devices are made by halogen lamps or LEDs fitted with PL (polarizing) filters to eliminated halation on glossy fruit surfaces. The near infrared inspection systems consist of halogen lamps and a spectrophotometer to analyze absorption bands of transmissivity light from fruits. X-ray imaging system is sometimes installed on each line to find internal defects such as rind puffing.

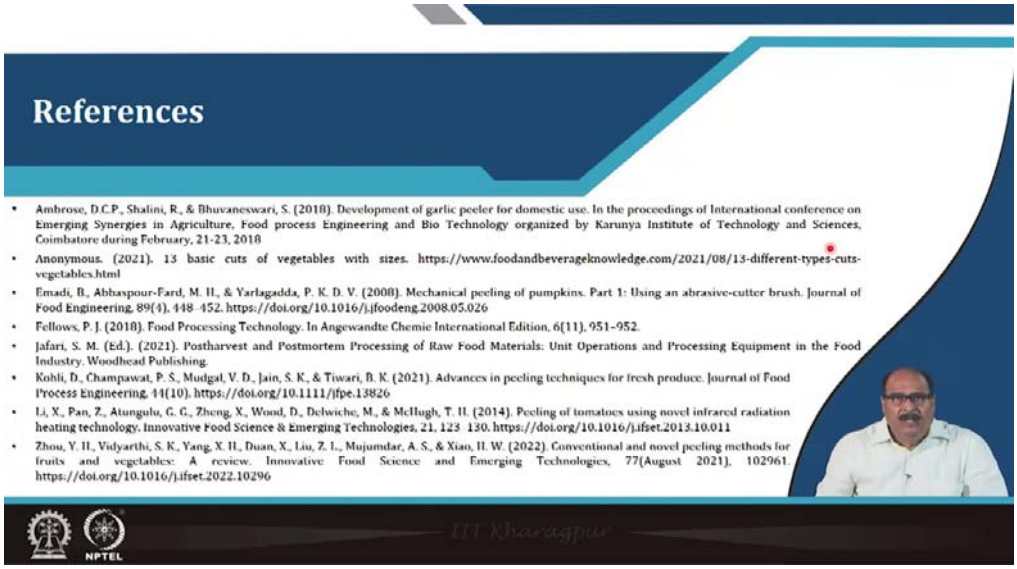


Robotic grading system

A grading robot for deciduous fruits such as peaches, pears, and apples to automatically provide fruits from containers and to inspect all sides of fruit. The robot system consists of two 3 DOF manipulators, in which one is a providing robot, while the other is a grading robot with 12 machine vision systems. After container comes under the providing robot (1), 12 fruits are sucked up by suction pads at a time (2) and are transported to intermediate stage making space toward vertical direction on this page between fruits (3). The grading robot picks 12 fruits up again (4) and 12 bottom images of the fruits are acquired during the manipulator moving to trays on a conveyor line (5). Just before releasing the fruits to the trays (7), 4 side images of each fruit are acquired by rotating the suction pads (6). The fruits are pushed out onto a line (8) and top images are acquired by another colour camera stationed on each line. In this system, fruit colour, size, shape, and defect are measured.



In summary, fruit sorting and grading is an important process that affects the quality, management and storage of products. Manual grading is expensive, laborious and inefficient. The most important difference of the automation systems from the conventional machines is to be able to handle a lot of precise information. To handle the comprehensive data on agricultural products and foods, understanding of diversity and complexity of biomaterial properties is required and sensors to collect data should be often designed based on the properties. Machine vision technologies are utilized and improved with engineering design to convey fruits to detect fruit size, shape, colour, sugar content and acidity.



These are the references for further study lecture. Thank you.