Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Welcome to the NPTEL online certification course on Modern Food Packaging Technologies Regulatory Aspects and Global Trends. Friends in the last class we have seen the packaging of dairy products for example, the ice cream and milk powder. In the following class we will be seeing the packaging of fruits and vegetables. And in this class we will be discussing first the introduction, then why should fresh fruits and vegetables be packaged and then factors affecting shelf life of fruits and vegetables. Now the introduction fresh fruits and vegetables are essential components of the human diet as they contain number of nutritionally important compounds such as vitamins and pigments that cannot be synthesized by the human body. A fruit or vegetable is a living respiring and edible tissues that has been detached from the parent plant.

Fruits and vegetables are perishable products with active metabolism during the post harvest period. In simple terms the shelf life of fruits and vegetables can be extended by retarding the physiological, pathological, physical, deteriorative processes generally referred to as post harvest handling or by inactivating the physiological processes generally referred to as food preservation. Packaging fresh fruits is one of the more important steps in the long and complicated journey from grower to consumer. Bags, crates, hampers, baskets, curtains, bulk bins and palletized containers are convenient containers for handling, transporting and marketing fresh produce.

Although the industry generally agrees that container standardization is one way to reduce cost, the trend in recent years has moved towards a wider range of package sizes to accommodate the diverse needs of wholesalers, consumers, food service buyers and processing operators. Packaging and packaging materials contribute a significant cost to produce industry. Therefore, it is important that packers, shippers, buyers and consumers have a clear understanding of the wide range of packaging options available. The Andhra Pradesh, Maharashtra, Uttar Pradesh, Gujarat and Madhya Pradesh are the five states which are producing fruits in the maximum quantity. Whereas, the West Bengal, Uttar Pradesh, Madhya Pradesh, Bihar and Gujarat they produce vegetables in the maximum quantity.

In India's total horticultural produce is stood 313.8517 million tons in the year 2018 and 19. Whereas, during 2019 and 20 India exported fruits and vegetables worth 1.3 billion

US dollars in which the fruit share was 668.75 million dollar and the vegetable share was 608.
48 million US dollars. The major destinations for Indian fruits and vegetables where the countries like Bangladesh, UAE, Netherlands, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar. If we see the total production, the total production the banana was the highest production followed by the mango and citrus fruits and this graph has been given the production of different fruits in 1000 metric tons. Now, why should fresh fruits and vegetables be packaged? Packaging is essential to preserve the freshness of fruits and vegetables and their flavor and nutritional value. Packaging slows down the decay process and preserves the freshness of the products by keeping them in moisture free environments.

They ensure that the products remain in hygienic environment during transportation storage and sale. In this way they prevent the contamination of germs and bacteria by exposing the products to environmental factors. Packaging provides easy transportation and storage of products. This prevents products from being damaged and spoiled. The factors affecting shelf life of fruits and vegetables.

The first is respiration, temperature and relative humidity, nutrients, volatiles, supply of carbon dioxide and oxygen, wounds and bruises, type, cultivar and stage of maturity and at and the last is presence of pathogens and pests. Now, the first factor is respiration. Fresh produce respire even after harvesting. During this period oxygen is used and carbon dioxide is released. The rate of deterioration is proportional to the high respiration rate.

Rapid respiration results in fast ripening or aging of the produce. If the availability of oxygen is restricted it results in changes in chemical reactions, breakdown of sales, production of small quantities of alcohol, off flavor and off odor and finally, bringing about decay or spoilage of the fresh produce. The more respiration less is the shelf life of fruits. Higher respiration leads to rapid breakdown of carbohydrates to carbon dioxide and water and it can be shown as follows. Glucose plus 6 oxygen produces 6 molecules of carbon dioxide and 6 molecules of water along with some energy.

Respiration rate is affected by temperature, humidity, supply of oxygen and carbon dioxide, maturity condition of fruits and its water, sugar and other food material content and higher concentration of sugar within the tissues. Tissue moisture have a direct relationship with the respiration rate. This table gives the range of respiration rate and their classification based on the respiration rate. The very low respiration rate is indicated by less than 5 milligrams of carbon dioxide emission per kg per hour and the commodities are dates, dried fruits and vegetables, nuts etc. The apple, beat, citrus,

garlic, grape, onion, papaya, pineapple, potato they are categorized as low respiration rate material having 5 to 10 milligrams of carbon dioxide per kg of produce per hour at 5 degree Celsius temperature.

Likewise, the other fruits and vegetables are categorized into moderate, high, very high and extremely high and the range is given like this and the products are this. Fruits classified according to their respiratory behavior into two categories such as climacteric fruits and non climacteric fruits. The climacteric fruits they are the products as a whole emit a greater amount of ethylene as the fruit ripens and after ripening peaks their ethylene production drops off by a significant amount. Because of this climacteric fruits tend to ripen quickly and will develop flavor and aroma. Non climacteric fruits, non climacteric produce is quite opposite and simply does not ripen after the product has been harvested.

They react differently to ethylene and carbon dioxide levels when they come into contact with them. The adjacent graph shows the rate of respiration versus time and it can clearly be seen that the climacteric fruit after plucking it goes down to a minimum level and then with time it increases sharply that is known as climacteric rise and when it reaches a climacteric peak then it decreases sharply and the senescence or the spoilage of fruit starts. Whereas in the non climacteric fruits the rate of respiration goes down with respect to time continuously. The fruits classified according to their respiratory behavior during ripening. The climatic examples of climatic fruits are apple, apricot, avocado, banana, bread fruits, figs, guava, jackfruit etcetera and the non climatic fruits are blackberry, cocoa, carambola, cashew apple, cherry, cucumber etc.

Temperature and relative humidity, temperature and relative humidity are the most important factors determining shelf life of fruits. If fruits are stored at low temperature and humidity they will deteriorate within a very short time. Low temperature and high relative humidity increases shelf life of fruits. Both high temperature and high relative humidity are harmful for fruits as they increase respiration rate and also infestation by insect, pest and pathogens. The adjacent figure shows the storage of orange or the fruit at different temperatures.

If it is stored at 5 degree Celsius then it does not ripen, but at the same time the disease develops. When it is stored at 8 degree Celsius then it ripens slowly, but when it is stored at slightly higher temperature at 20 degree Celsius then the ripens fast and when it is stored as still higher temperature that is 30 degree Celsius then orange color develops and spoilage starts. So an optimum temperature storage must be chosen for a individual fruit or vegetable product. This table gives the life of different fruits and vegetables with their temperature and approximate shelf life of that. Like for example, the grapes if it is

stored at minus 1 degree Celsius then its shelf life will be about 6 weeks.

Pears minus 1 degree Celsius temperature storage it will go up to 21 days. The onions minus 5 degree Celsius temperature it will go up to 21, 28 days. Likewise for different fruits and vegetables the storage temperature is listed and the corresponding storage life in weeks are listed in this table. The next important factor is nutrient. Respiration rate increases if fruits contain more sugar and water and so the fruits spoil very rapidly.

Now, volatiles some fresh produce give off volatile compounds such as ethylene during ripening. If these volatiles are not allowed to escape unacceptable odour develop and the produce ripens rapidly. Ethylene production rate depends upon variety, maturity stage, temperature, oxygen level, carbon dioxide level of the fresh produce. The product drops especially sensitive to ethylene. The leafy vegetables they turn yellow, russet spotting on leaves and abscission of leaves if they are stored in ethylene.

Likewise cucumbers they turn yellow and become soft. Like fruits they accelerates ripening. Flowers they will develop wilt and or drop off. The supply of carbon dioxide and oxygen. Altering the concentrations of oxygen and carbon dioxide around products can inhibit respiration and increase storage life due to reduced alloying and softening.

Supply of more oxygen increases respiration rate on the other supply of carbon dioxide decreases respiration rate. The previous section discussed the principle of respiration that is the respiration follows the equation that is all the carbohydrates in presence of oxygen they produce carbon dioxide and water molecule plus some energy. As the products respire they use oxygen and release carbon dioxide. This suggests that reducing the concentration of oxygen and or increasing the concentration of carbon dioxide can inhibit respiration and extend shelf life. While this can be true oxygen often needs to be reduced to quite low concentration before rise respiration is greatly inhibited.

The figure below shows a typical relationship between respiration rate and concentration oxygen concentration. The respiration is not significantly inhibited until oxygen falls below 5 degree Celsius. One can see the oxygen concentration has to be reduced to below 5 degree Celsius to reduce the carbon dioxide production level. And after certain period if the oxygen is further reduced then again respiration starts, but this time the respiration will be anaerobic respiration with production of carbon dioxide. The effect of oxygen concentration on respiration rate measured as carbon dioxide production respiration is not greatly inhibited until oxygen falls below 5 degree Celsius.

However, if oxygen falls below 1 percent then anaerobic respiration occurs and carbon dioxide production actually increases which we have seen in the last figure. Responses to

altered atmosphere vary widely between different vegetables. In many cases respiration may be less affected than other factors that impact on storage life. Potential effects include reduced production of ethylene, reduced sensitivity to ethylene effectively slowing down color change and ripening in fruits and vegetables, improved retention of green color due to reduced breakdown of chlorophyll, reduced softening due to retention of pectins that holds cell walls together, less breakdown due to rots and diseases, growth of some fungal diseases is reduced when carbon dioxide is 10 percent or more. Wounds and bruises, bruising affects several physiological processes and changes in physicochemical quality parameters as well as the nutritional value.

When cell content is released into intracellular spaces due to cell damage some cell constituents like phenolic compounds can undergo oxidation and turn brown. Internal browning is one of the classic symptoms of bruising that develops even with slight tissue damage. Wounds and bruised fruits show high rate of respiration as a result these fruits rot quickly and become unfit for consumption. Bruising significantly affects physiological processes like fruit respiration, ethylene production and transpiration. The respiration rate is increased for example, in sweet potatoes by 72 percent this rise in respiration and the bruising stress increase production of ethylene a phytohormone responsible for ripening and senescence.

Ethylene is also released in response to pathogenic infection. Faster ripening in the bruised parts can follow increased respiration and ethylene production rates reducing the shelf life of the fruits. Bruising leads to significant moisture loss, reducing fruit freshness and shriveling and weight loss. For example, a single bruise on the apple increase the moisture loss rate by up to 400 percent. Senescence is more in bruise fruits due to post harvest ruts and decay than in unbruised fruits.

It can result from microbial spoilage or get accelerated due to high ethylene production. Now, the type cultivar and stage of maturity. The shelf life of fruits is dependent on the type cultivar and stage of maturity. For example, ripe bael can be stored for long period, but bananas can be stored only for a few days. Fruit coat plays a great role in this respect.

Again shelf life may vary depending on the cultivar of the same fruit. For example, in normal conditions shelf life of mango is 2 to 3 days longer than other fruit varieties. The presence of pathogens and pests. The presence of pathogens has an adverse effect on the shelf life of fruits. In high temperature and high humidity pathogens infect fruits at severely.

At high temperature and high humidity the fruit is unfit for consumption within 2 days.

Buy an insect pest that is fruit borer, cockroach, flies make wounds on the fruits and help to start the rotting of the fruits. Thank you very much.