

Module on Preservation Of Vegetables

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Introduction:

Vegetables and fruits are parts of plants which can be consumed both as raw and processed products. Fruits are developed from flowers which produce seeds, while vegetables are produced from any part of the plant. However, vegetables like tomatoes, cucumbers, peppers, egg plant, lady's finger and sweet corn are actually seed bearing fruits. Based on consumer's acceptance and usage, vegetables are those part of plants which are consumed with the main course of meal. The top ten states productions of vegetables of our country are shown in **Table 1.**

Classification and nutritive contents of Vegetables:

Vegetables not only make the food attractive by their colour, texture and flavour but also provide nutrients. Though, Indian population is mainly vegetarian, consumption of vegetables is comparatively low. This could be because of their non-availability throughout the year or because of their cost. Further, they are perishable, and the consumption is limited due to stringent storage facility in our Indian conditions.

Vegetables used as food can be classified into groups based on their growing season or based on parts of plants consumed. The classification of vegetables according to the parts of plants consumed or colour of the vegetable is given in **Table 2**.Vegetables are known as protective foods being rich in minerals and vitamins. As per Indian council of medical research (ICMR) balanced food protocol, vegetables are classified into:

- Green leafy vegetables
- Roots & tubers vegetables
- Other vegetables.

<u>Green leafy vegetables</u>: Leaves are photosynthetic organs of plant and supply carbohydrates to other parts of the plant. As a result, leaves contain low amount of carbohydrates. However, they are good source of β -carotene, calcium, riboflavin, folic acid, ascorbic acid, iron & vitamin K. They play an important role in the diet and health of a consumer.

Generally green leafy vegetables are good sources of vitamins and minerals. They are

rich in carotenes which get converted to vitamin A. Among all the greens, colocasia leaves contain highest amount of carotene and cabbage has the least. β -carotenes are also good antioxidants. Green leafy vegetables are also rich in iron, for example spinach and red amaranthus. Agathi, colocasia leaves, drumstick leaves and fenugreek leaves contribute significantly for calcium in our diet. Greens are good sources of fibre which helps in preventing degenerative diseases. However, drying and wilting reduces vitamins.

<u>Roots and tuber vegetables</u>: Roots and tubers give more calories than leafy vegetables. Carrots contain high amount of carotene but still lesser than green leafy vegetables. Roots and tubers are fairly good sources of vitamin C but are poor source of calcium, iron and B-vitamins.

Other vegetables: These are highly perishable but fairly good source of vitamin C. These contribute to the fiber content of the diet. Plantain green or raw banana contains high amount of iron, while capsicum contains vitamin C. Bitter gourd is quite nutritious and has curative properties against diabetes. Bright colours of many vegetables is due to variety of pigments present in their tissues which are either water soluble (anthocyanins, Betalains and anthoxanthins) or water insoluble (chlorophyll & carotenoids). Further, these are rich in organic acids such as formic, citric, malic, succinic, tartaric, fumaric and benzoic acid etc.

Carotenoids present in carrots, oranges and spinach prevent oxidation of vitamin A and E. Limonoids present in citrus peel act as antioxidants protecting lung tissues from free oxygen radicals. Phenolic compounds present in berries, grapes and brinjals protect against oxidative damage of tissues and inflammation. Cruciferous vegetables are rich sources of glucosinolates. They activate liver detoxification enzymes and can reduce tumor. Alyric sulphide is a potent antimutagenic and anticarcinogenic. Indoles found in citrus and gooseberry are anticarcinogenic and protect against cancer.

Storage of Vegetables:

Most vegetables are consumed fresh. However, they can be stored depending on their type. Root and tuber vegetables such as potatoes, onions and turnips can be stored for few days, while beans, peas, cauliflower, cucumber, tomatoes and asparagus can be stored only

for a few days. Storage of vegetables brings compositional changes. Storage temperatures for vegetables depend on their processing. For instance, potatoes meant for dehydrations and chips manufacturing are stored at temperature above 10°C, so that they have low sugar to minimize maillard browning. In contrast, potatoes for fresh consumption are stored below 10°C to allow high levels of sugar. Low respiring vegetables have a long shelf life in contrast to the short life of high respiring forms. Storage of vegetables at 1 to 4°C with humidity of 80 – 95% Rh is the most appropriate method.

Changes during storage of vegetables:

During storage, weight loss ranges from 2-10%, ascorbic acid and carotene content decreases, degradation of starch and pectin occurs. In some vegetables, such as cauliflower, lettuce and spinach, the free acid content increases during freezing or frozen state of storage.

Waxing: The principle of application of wax emulsion is based on partial coverage of surface cells of vegetable there by reducing respiration rates. This helps in the extension of storage life. Wax coating prevents moisture loss, maintains the appearance, decreases rate of decay & sprouting.

Modified atmosphere packaging (MAP): MAP is the method for extending the shelf life of perishable and semi-perishable food products by altering the relative proportion of atmospheric gases that surround the food.

Harvesting at optimum maturity with minimum injuries, and with proper sanitation procedures extends the shelf life. This, along with providing optimum storage conditions namely temperature, humidity and other storage atmosphere like appropriate gas maintenance, promotes the shelf life. One common method is to adjust the permeability of packaging to match the respiration of the vegetable so that O2 concentration is reduced and CO2 is higher. Such a mixture reduces the rate of respiration, inhibits the synthesis and retards the microbial growth. The storage life of different vegetables in MAP are given in **table 3**

Fresh vegetables as salad includes uncooked, raw or green vegetables seasoned with salad dressing are consumed throughout the world. Salad is prepared by mixing sliced or diced carrot, onion, cabbage, cauliflower, lettuce, spinach, cucumber, beet root are served as appetizer or first course or as a separate course of meal.

Preservation methods for vegetables are as follows:

- Dehydration of vegetables
- Fermentation of vegetables
- ✓ Pickling of vegetables
- ✓ Canning of vegetables
- ✓ Vegetable concentrates, juice and powder and puree
- ✓ Refrigeration and Freezing
- ✓ Irradiation

Dehydration of vegetables:

Drying is the process of preservation by removing water from it. Drying foods is carried out by various methods like sun drying, air drying, heat drying and wind drying or drying near an open fire. Removing water prevents decay and the growth of microorganisms. This method of food preservation has been known since ancient times. Principle of drying is based on management of water activity, lesser the water activity more the shelf life of the food product. Dehydration reduces the water content of the food products leading to reduction in water activity, hence extending shelf life. Drying alters the texture of the food, typically concentrating which, in turn modifies the taste. Dried food being safe to store, hardly requires any special storage condition. Dehydration reduces the moisture content of vegetables below the required level, limiting growth of microorganisms, but changes the flavour, aroma and appearance. During concentration proteins, carbohydrates and minerals undergo chemical changes. Fats are oxidatively degraded with reduced odour and flavour. Maillard reaction results in darker colour. Vitamins and original volatile flavour and aroma compounds are also reduced.

Prerequisite for dehydration of vegetables

Vegetables are washed, peeled, cleaned and may be sliced or diced prior to dehydration. Blanching for 2-7 minutes using hot water or steam and SO2 inactivates the native enzymes. Vegetables, are then dehydrated in a conveyor tube drier at 55-60°C till it reaches final moisture content of 4-8%. Liquid or paste forms, such as tomato or potato mash are dried in a spray or drum drier. Dehydration is done either by freeze drying or sun drying. Freeze drying yields high quality products like peas and cauliflower for the production of soup powder.

India is the major producer of dried and preserved vegetable like preserved onions, cucumber and gherkins. India is also the leader in products like dehydrated mushrooms, truffles, green pepper in brine, asparagus dried, dehydrated garlic powder, dehydrated garlic flakes, dried potatoes etc. India is a prominent exporter of dried and preserved vegetables to the world. Country has exported 66,189.61 MT of dried and preserved vegetables to the world worth Rs. 914.21 cores during the year 2015-16. The exports were mainly to Germany, United Kingdom, United States, Russia and Belgium.

Fermentation of vegetables: Internationally the most popular fermented vegetable is sauerkraut prepared from cabbage. Most of the fermented products are lactic fermentation. Spontaneous lactic acid fermentation of vegetables such as cabbage, cucumber and beans yield good quality fermented vegetables. Fermentation lowers the pH, inhibits the growth of spoilage microorganisms. Further it aids in enzymatic softening of cells and tissues, thus improving the digestibility and wholesomeness of the vegetables. Salt is added as a preservative and to facilitate fermentation. Cucumber (unripe ones), sauerkraut (white cabbage) and vinegar (Pickled vegetables) are the example for pickled vegetables. *Leuconostoc mesenteroides* dominates, producing a mix of acids, alcohol, and

aroma compounds. At higher temperatures *Lactobacillus plantarum* dominates, which produces primarily lactic acid.

Pickling of Vegetables:

Pickling is the process of preserving food by anaerobic fermentation in brine or vinegar. The resulting food is called a pickle. This procedure gives the food a salty or sour taste. In South Asia, vinaigrette (vinegar and vegetable oil) are used as the pickling medium. Typical pickling agents include brine (high in salt), vinegar, alcohol, and vegetable oil. Commonly made pickles are: mango, cucumber, green chilli, lemon, and amla. Another distinguishing characteristic is pH maintained at less than 4.6, which is sufficient to kill most bacteria. Pickling can preserve perishable foods for months. Antimicrobial herbs and spices such as mustard seed, garlic, cinnamon or cloves, are often added. If the food contains sufficient moisture, brine may be produced simply by adding dry salt. Other pickles are made by placing vegetables in vinegar. Unlike the canning process, pickling (which includes fermentation) does not require food to be completely sterile before it is sealed. The acidity or salinity of the solution, the temperature of fermentation type of microorganisms and the exclusion of oxygen determines which flavour dominate in the end product.

In chemical pickling, the jar and lid are first boiled to sterilize them. The fruits or vegetables to be pickled are then added to the jar along with brine, vinegar, or both. Spices are added as required and are then allowed to ferment until the desired taste is obtained. The food can be pre-soaked in brine before transferring to vinegar. This reduces the water content of the food which would otherwise dilute the vinegar. This method is particularly useful for fruit and vegetables with high water content.

Canning of vegetables:

Canning is an important, safe method for preserving food if practiced properly. Canning involves cooking food, sealing it in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization. Canned goods can be stored on shelves for years. There are two methods, i.e pressure canning method and other is simple canning method.

The freshly harvested vegetables are cleaned, trimmed, sorted, graded and blanched. Blanching inactivates the native enzymes and also removes undesirable flavour compounds and the air inside the plant tissues. During this heating process air is driven out of the jar and as it cools a vacuum seal is formed. Vacuum seal prevents air from getting back into the product which brings contaminating microorganisms. Simple canning also known as the boiling water bath method is safe for tomatoes, fruits, jams, jellies, pickles and other preserves. In this method, jars of food are heated completely covered with boiling water and cooked for a specified amount of time. Pressure canning is a safe method of preserving vegetables, meats, poultry and seafood. Jars of food are placed in 2 to 3 inches of water in a special pressure cooker which is heated to a temperature of at least 112° C. This temperature can only be reached using the pressure method.

Problems associated with Canning: Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened. Lack of quality control in the canning process may allow invasion of water or micro-organisms. Canned food can be a major source of dietary salt (sodium chloride). Too much salt increases the risk of health problems, including high blood pressure.

<u>Vegetables concentrates, Juices and powders</u>: Vegetable puree or paste are finely dispersed slurry of the vegetable such as tomato. After removing the skin and seeds, the vegetable is passed through a pulping machine. Juices of tomatoes, cucumber, carrots, radish, red beet and cabbage are obtained by disintegrating the cleaned and bleached vegetables. The juice is filtered or centrifuged and salt (0.2 - 1.0 %) is added. The juice is pasteurized for improved storage.

Vegetable powders are produced by spray drying, vacuum drum drying or freeze drying the vegetable juice with or without the addition of a drying enhancer such as starch to a residual moisture content of 3%. Tomato powder is the most important product. Spinach and red beet powder are used for food colouring.

Refrigeration and Freezing:

Freezing fruit and vegetables soon after they are picked serves to 'lock in' the flavour and freshness of the produce. Freezing and then thawing a vegetable or fruit is the preservation method wherein end product resembles the taste of fresh food. It is recommended that vegetables are blanched before freezing them. This limits the activity of enzymes, thus, preventing spoilage during storage. For effective long term storage temperature, below freezing point is recommended. When thawing food, leave at room temperature until completely thawed, rather than trying to thaw in the oven.

Refrigeration and freezing are probably the most popular forms of food preservation in use today. In the case of refrigeration bacterial action slows down. Thus, requires longer time to spoil. In the case of freezing, bacterial action is almost stopped or arrested. Frozen bacteria are completely inactive.

Refrigeration is done for short duration storage. Water makes up over 90 percent of the weight of fruits and vegetables. This water and other chemical substances are held within the fairly rigid cell walls which support structure and texture to the fruit or vegetable. Deep freezing is advised for longer duration storage. Freezing fruits and vegetables actually consists of freezing the water contained in the plant cells. When the water freezes, it expands and the ice crystals cause the cell walls to rupture. Chemical changes during freezing and refrigeration can lead to the development of rancid oxidative flavors. This problem can be controlled by using a wrapping material which prevents air to pass into the product.

Irradiation: One of the important method for the preservation of onions, potatoes, garlic and carrots are preserved throughout the world is Irradiation. The advantages of this method is limiting sprouting and rotting without changing chemical and nutrient composition. It can be can be used to treat produce in large quantity. Low quantities of isotopes are used in this method so, there is a perception that it carries radioactive material which experiments throughout the world has shown, is not true.

Conclusion: India stands second largest producer of fruits and vegetables in the world. Vegetables are one of the most important food inputs for human beings. However, due to highly perishable nature vegetable has to be used within short time after harvesting. Various methods have been used traditionally like fermentation, drying, pickling etc. Irradiation refrigeration and freezing are the modern methods for preservation. Modified atmospheric packaging too contributes significantly to extend the shelf life of vegetables. Nutritionally and economically the preservation of vegetables has immense potential to human health.

SI No	States	Production (in 000 Metric tons)		
JINO	West Bengal	26354.61		
	Uttar Pradesh	23575.61		
	Bihar	14467.15		
	Madhva Pradesh	14315.41		
	Guiarát	11543.29		
	Odisha	9425.13		
	Karnataka	8564.77		
	Maharashtra	8136.26		
	Andhra Pradesh	6445.60		
	Chhattisgarh	5739.51		

Table – 1, Top 10 Vegetable Producing States: 2014-2015

Source: http://www.mospi.gov.in/

Table – 2 : Classification of vegetables

Groups	Vegetables			
Roots	Carrots, beet root, radish, turnip, Colocasia			
Tubers	Potatoés, sweet potato, tapioca			
Bulbs	Onion, garlic, leeks			
Leaves	Cabbage, lettuce, spinach, amaranth, fenugreek leaves, coriander			
	leaves, mint leaves			
Flowers	Plantain flower, cauliflower, neem flower, broccoli			
Fruits	Tomatoes, Brinjal, lady's finger, pumpkin, cucumber-, gourds (ash gourd,			
	bottle gourd, ridge gourd), capisum, drumstick, plantain, avocado, bread			
	fruit			
Legumes	Peas, beans, choli, broad beans, French beans, double beans, bengal			
	gram tender, red gram tender			
Stems	Plantain stem, ginger, amaranth stem, celery stem, lotus stem,			
	asparagus, bamboo shoots			
Seed sprouts	Green gram, Bengal gram, sovbean sprouts, sweet corn			
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Table - 3: Storage of vegetables in MAP

Vegetable	Storage temp (in °C)	Oxygen (in %)	Carbon-dioxide (in Percentage)	Approximate storage (in months)
Beets	0-5	None	None	8
Brinial	8 – 12	-	-	$\frac{1}{4} - \frac{1}{2}$
Cabbage	3-5	5-7	-	6 – 12
Carrot	0-5	None	None	4 – 5
Cauliflower	0-5	2-3	3-4	2-3
Celerv	0-5	1-4	3-5	1-2
Cucumber	8 – 12	3-5	0	$\frac{1}{2} - \frac{3}{4}$
Lettuce	0-5	2-5	0	3/4 - 1
Lady's finger	8 – 12	3-5	0	$\frac{1}{4} - \frac{1}{2}$
Pumpkin	7 - 10	-	-	2-4
Spinach	0-5	Air	10-20	$\frac{1}{2} - \frac{3}{4}$
Tomatoes	5 – 13	3-5	2-3	1/2