A series On
Food Science and Technology

Lecture on
Value addition to Fruits and Vegetables through Processing

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1.0 Introduction

Fruits, vegetables and their products have gained considerable importance by contributing significantly to the nutrition and economy of many countries in the world. Along with economic development there is a general trend world over towards increased demand for fruits and vegetables as major components of the diet. They not only contribute to the food value but are vital sources of essential minerals, vitamins and dietary fiber. In addition to these constituents, they supply complex carbohydrates, protein and energy. Almost all vegetables are excellent sources of minerals and add bulk to the diet thereby contributing strongly to good health.

Fruits and vegetables being highly seasonal and perishable commodities, it has been an endeavor world over to evolve methods to prevent losses of these commodities between harvesting and consumption. The losses are estimated to be of the order of 25-30% in many tropical and sub-tropical countries. Processing these crops into shelf stable and value added product is one of the most common methods to minimize the losses.

Processing of fruits and vegetables besides curtailing post-harvest losses can add value, extend season, ensure better economic utilization of fruits and vegetables and impart convenience. With their exotic flavor and variety there is an increasing demand for tropical and subtropical fruits and vegetables and their products. Depending on the method of processing, the nutrient content of the foods are lost to varying extent. One of the major objectives of technological developments in food processing is minimizing these losses. Hence processing conditions should be such that processed products will have minimum loss of nutrients present in the raw materials. For continued viability of fruit

processing industry, it is necessary to keep pace with changing technological developments to provide processed products having better quality and variety.

This episode deals with

Production of fruits and vegetables
Post- harvest losses
Primary processing
Processing technologies and
Processed products

2.0 Production of Fruits and Vegetables

The diverse agro climatic conditions viz. tropical, sub-tropical, temperate, arid and semi arid prevalent are conducive to the growth of wide varieties of fruits and vegetables in many countries. India has emerged as a major player among fruit and vegetable producing countries, occupying the second position with the current production of over 150 million tons (50 MT of fruits and 98 MT of vegetables). (Table 1 and 2) **(1).**

Processing of fruits and vegetables also enables conservation of the crops besides imparting convenience and value addition The major fruits grown are mango, banana, citrus, pineapple, apple, grapes, sapota, papaya, and litchi. The other fruits, sometimes referred to as minor fruits like Aonla, Passion fruit, Annona, Mangostein, Avocado, Bael, Olive, Jackfruit, Jamun etc., have potential for their commercial exploitation. Similarly, a large variety of vegetables are grown in the country the major among them are: brinjal, cabbage, cauliflower, okra, onion, peas, potato and tomato.

Table 1. Area and Production of Fruits in India.

Sl No	Crop	Area (In million Ha)	Production (In MM tons)
1.	Banana	0.50	17.50
2	Mango	1.50	11.40
3	Citrus	0.53	4.80
4	Papaya	0.07	1.70
5	Guava	0.16	1.85
6	Apple	0.24	1.30
7	Pineapple	0.07	1.10
8	Grapes	0.04	1.20
9	Sapota	0.07	0.90
10	Litchi	0.06	0.45
11	Others	0.70	9.60
	Total	3.94	49.80

Table 2. Area and Production of Vegetables in India.

Sl No	Crop	Area (In million Ha)	Production (In MM tons)
1.	Potato	1.38	26.00
2	Brinjal	0.51	8.80
3	Tomato	0.50	8.40
4	Cabbage	0.28	6.10
5	Onion	0.52	6.50
6	Cauliflower	0.26	4.80
7	Okra	0.34	3.50
8	Peas	0.30	3.80
9	Others	2.13	30.60
	Total	6.24	98.50

Besides the major tropical and sub-tropical fruits, the second category of fruits classified as minor or underutilized, constitute a very large number of fruits. Important fruits in this category are listed in Table 3.

Table 3 : Some minor fruits

Cashew apple	*(Anacardium occidentale)*
Custard apple	*(Annona squamosa)*
Jack fruit	*(Artocarpus heterophyllus)*
Karonda	*(Carissa carandas)*
Kokam	*(Garcinia indica)*
Litchi	*(Litchi chinensis)*
Pomegranate	*(Punica granatum)*
Sapota	*(Arachas sapota)*
watermelon	*(Citrullus vulgaris)*

Some of these crops are cultivated and also grow widely in many countries. Though substantial quantity of these fruits is produced, reliable production data for these fruits are not available. Many are known for their therapeutic, medicinal and nutritional value and have very good demand. Except for litchi, which is commercially processed, the other fruits are rarely processed. In recent years considerable R & D work has been carried out to develop products from these fruits. The technologies developed, if put to use could enable better economic utilization of these crops, some of which have potential for extensive cultivation in arid and semi-arid regions.

3.0 Post- Harvest Losses

Post-harvest losses in fruits and vegetables in most of the tropical developing countries is very high due to adverse climatic conditions, inadequate infrastructural facilities and the inherent physiological nature of the crops (Table 4). Being highly perishable and seasonal in nature, unless suitable measures are taken, fruits and vegetables deteriorate in quality and value and ultimately lead to losses. Therefore, the conservation measures should start from pre-harvest orchard management to control microbial and insect infestation, harvesting at the optimum stage of maturity, adopting appropriate methods and careful handling of the commodities throughout the handling chain.

Table 4: Post harvest losses in Fruits and Vegetables

Fruits	Loss (%)	Vegetable	Loss (%)
Mango	**25-30**	**Beans**	**4-12**
Banana	**15-25**	**Cabbage**	**17-27**
Papaya	**30-50**	**Carrot**	**4-8**
Orange	**15-25**	**Brinjal**	**5-11**
Grapes	**20-34**	**Okra**	**4-14**
Apple	**10-18**	**Tomato**	**22-38**
Peaches	**20-36**	**Cauliflower**	**41-47**
Apricots	**18-38**	**Potato**	**15-29**
		Onion	**19-31**

4.0 Value addition by Processing

Fruits and vegetables are processed into a large number of value added products in the country. There are about 4930 FPO licensed units in the country with a total installed capacity of 2.04 million tons. The production of processed fruit and vegetable products has shown a steady increase over the years and presently it is around 0.96 million tons

4.1 Primary processing operations

For better sanitation, storage stability and in order to improve the nutritional qualities, of processed products, fruits and vegetables undergo certain common unit operations such as selection, handling, sorting, washing, peeling and slicing which are briefly discussed.

4.1.1 Selection:

The quality of the processed product depends largely on the quality of the incoming fruits. Therefore, it is important that fruits and vegetables of right quality suitable for different processed products are produced. This has led to the captive production of the crops by the processing units or enter into contract farming. An understanding of harvest principles can help the decision makers to plan operations that results in highest fruit quality possible within specified economic constraints. Harvesting the fruits at its optimum stage of maturity, optimum colour, size etc. is carried out mechanically or by manual harvesting. Most mechanized harvest techniques rely on mass removal of fruit, which usually results in more damage than is commonly found with manually harvested fruits.

4.1.2 Handling: An understanding of the mechanical properties of fruits enables the design of conveyors, lowerators, containers and other equipment's that minimize bruising. Bulk handling methods are rapidly being adopted to reduce cost and to enable increased mechanical harvesting rates. Impact during handling of fruits is one of the most common causes of bruises and results in large economic losses. Impact occurs when the fruit is harvested (either manually or mechanically) during movements to containers, while in transit, upon container dumping and during handling at processing plant. Reduction in bruising would increase promising yields and permit longer storage periods for raw materials.

4.1.3 Sorting: Sorting is performed to segregate material into lots based on fruit characteristics such as maturity, colour, weight, size, defects and firmness. Sorting of fruits enhances the value of the crop by providing a more uniform product. Sorting methods can be categorized as manual, mechanical or electronic.

4.1.5 Washing, peeling and Slicing: Fruits and vegetables are washed to remove dirt, dust, insect, mold, spores, plant parts and filth that may affect the colour, aroma or flavour of the fruit. To be most effective and economical, washing with water must be accompanied by brushing, rubbing and forcing the water against the fruit and into crevices. Detergents are frequently used in the wash or rinse water. Washing with water is always supplemented with air currents to remove light material and perforated or rod screens to remove small and heavy materials.

Peeling is one of the most important preparatory steps in processing of some of the fruits and vegetables meant for canning, freezing and dehydration. The selection of proper peeling method is of importance as the quality of the finished product depends, to a large extent upon the method used. Various peeling methods such as hand peeling, peeling by heat, lye peeling, acid peeling, dry caustic peeling, calcium chloride peeling, and mechanical peeling are followed.

5.0 Processing technologies:

A large number of traditional technologies have been in vogue since time immemorial for fruit and vegetable preservation. They include: pickling, drying, fermentation, preservation in high sugar / honey etc. Many of these methods have evolved into modern technologies. Simultaneously newer technologies like thermal processing particularly aseptic processing, freezing, vacuum concentration, membrane processing etc. have also emerged. A few of the widely practiced technologies are enumerated below.

5.1 Thermal Processing:

Processing of fruit and vegetable products in open top sanitary cans is widely practiced. Many vegetables like potato, okra, bitter gourd, beans, cabbage, tinda, parval and fruit products like mango and other fruit pulps, pineapple slices, litchi, guava etc., are canned. For thermal processing, tinplate cans are the predominant packaging material, but glass bottles, are also used to a limited extent. Possibilities of using retort able pouches, aluminum cans, tin free steel plate etc., have been established and these are likely to be used widely in the near future.

Further improvement in quality of thermally processed foods has been achieved by High Temperature Short Time (HTST) processing as in the case of aseptic bulk and unit packaging.

5.2 Juice Extraction and Clarification:

The consumption of fruit juices has been increasing world over because of their richness in essential minerals, vitamins and other nutritive factors. Besides they are delicious and have universal appeal. In the juice recovery process, apart from thermal extractive heat extraction and the enzymatic liquefaction, mainly mechanical pressing systems such as i) hydraulic press, ii) pneumatic fruit juice press, iii) continuous plate press, iv) continuous screw type press v) horizontal basket press and vi) screening centrifuges are employed. Recently microbiologically produced plyphenoloxidases (9) and adsorber resins (10) have also been used. These fining agents not only eliminate existent browning but also link colourless oxidizable polyphenol and also diminish browning tendency. Recent developments have shown that adsorbent resins in combination with ultrafiltration can be used effectively for debittering of citrus juices and it's by products.

5.3 Fruit Juices, pulps and Concentrates:

Fruit juices, pulps and their concentrates occupy 27% of the total processed products. For fruit juice exrtaction, pulpers and presses are widely used. Juice clarification is usually achieved by Plate and Frame of Leaf filters, but micro and ultra-filtration are also being introduced for the purpose. Ultrafiltration adds value to the products by imparting better stability against sedimentation and the process is cleaner. Clarified fruit pulp/juices enable concentration to high solids concentrates. The steep rise in cost of packaging and also to have convenience, concentration of fruit juices has become a major unit operation. Concentration is achieved mainly in vacuum evaporators either in single or multiple stages (to reduce energy cost). Different types of evaporators like Calandria, plate, centrifugal, agitated film and scraped surface are used depending on the rheological as well thermal sensitivity of the products.

Aroma loss which is a major drawback in fruit juice concentration has been overcome by aroma recovery and restoration of the lost aroma.

Evaporation being energy intensive and liable for causing thermal damage to certain juices, membrane concentration process (reverse osmosis), has been established.

5.4 Drying and Dehydration:

Dried products are shelf stable and require less expensive packaging. Drying of some fruits and vegetables using sunlight is a traditional method. Even though some drying is still being used the more widely practiced method is by using different types of dryers where dehydration parameters can be more precisely controlled.

Batch dryers like the cabinet dryers are the common dryers for many products. Even though continuous belt dryers having better humidity control yields products having better reconstitution and sensory qualities, still they deviate significantly from the fresh material. Therefore, for more expensive and sensitive products like fruit cubes, freeze drying is applied.

5.5 Freezing:

Freezing has long been established as an excellent method for obtaining high quality food products. Generally it preserves the taste, texture and nutritional value of the food better than any other preservation method. As a result ever-increasing quantities of food are being frozen throughout the world. Freezing preservation of fruits depends on inhibition of post- harvest physiological changes along with inhibition of microbial action at low temperature. For prolonged storage the temperature must be well below the freezing point of water. Chilled food markets have experienced enormous recent growth and improvements in the nutritional and sensory qualities of novel heat processed foods which have comparable shelf like to the frozen counterparts have resulted in these preservation processes taking a considerable market share. In order to obtain high quality frozen foods, high quality raw material are necessary and processing distribution and storage must be carefully controlled. Frozen fruit chunks of mango, banana, guava and papaya and vegetables like peas, cauliflower, carrot, tomato etc. are being frozen and marketed.

An emerging technology for monitoring the temperature regime experienced by frozen foods during distribution and storage are temperature and time temperature indicators. These devices may be either threshold indicators which

show that the product has been held above a special abuse temperature or integrating devices that can reflect time and temperature dependent safety and quality changes.

A cost effective alternative to a 100% cryogenic IQF freezer is the use of combination freezers which use a combination of cryogenic and mechanical technique. The principle of operation of combination systems is to use a cryogenic freezing unit for initial freezing of the outer surface of the product, followed immediately by mechanical freezing to reduce the temperature of the bulk of the product to the desired frozen temperature.

Combination freezing system has also been developed for freezing of liquid, semi liquid foods such as fruit and vegetable purees. A combination treatment involving freezing in conjunction with irradiation has recently been proposed as means of reducing spoilage prior to or following processing. In order to preserve the high quality of frozen foods rapid freezing techniques such as fluidized bed and cryogenics are becoming more widespread.

Frozen products are near natural products. Though not widely produced in the country, their demand both in the domestic as well as export markets is increasing.

5.6 Pickling:

Pickles are traditional products in the country. High salt cured unfermented pickles and vinegar pickles. Modernization of the pickle industry by improving the various unit operations has enabled better and consistent quality and value. In order to reduce packaging cost, and impart convenience, dehydrated pickles based on mango, lime and several vegetables have been developed and commercially produced. Even though fermented pickles are rare in the domestic market, high value fermented gherkins worth more than Rs.200 million are exported from the country.

5.7. Osmotic dehydration:

Partial dewatering and direct formulation of fruit / vegetable pieces can be obtained immersing in the concentrated solution of salt or sugar. This process is known as osmotic dehydration or dewatering and impregnation soaking process. This process can be used as a pretreatment before any complementary processing steps such as drying, freezing, pasteurizing, canning and or the addition of preservative.

Fresh fruit pieces are first soaked in sucrose syrup (possibly blended with invert sugar) in batch system at normal pressure and at temperatures in the range of 30-80°C. Products are then air dried which leads to final water content in the range 15-20% (w/w). Osmo dried fruits are mainly prepared from pineapple, papaya, mango, jackfruit, banana, ginger etc. (11).

5.8 High sugar products:

High sugar products like preserves and candies are traditional products in the country. Raw papaya candy (Tuti fruiti) is an important commercial product, finding extensive use in bakery products.

Jams, Jellies and Marmalade are also produced to the tune of 10% of the total fruit and vegetable products.

5.9 Chemically Preserved Products:

The only two chemical preservatives permitted under FPO-1955 in the country are sulphur dioxide (and its sodium and potassium salts) and benzoic acid (and its sodium salt).

6.0 Processed Products:

A number of processed fruit and vegetable products are produced by the Indian food industry, the percent break up of which is presented (Table 5).

Table 5 : CATEGORIES OF FRUIT AND VEGETABLE PRODUCTS

CATEGORY	(%)
FRUIT JUICES AND PULPS	27
RTS BEVERAGES	13
PICKLES	12
JAMS AND JELLIES	10
SYRUPS	8
SQUASHES	4
TOMATO PRODUCTS	4
CANNED VEGETABLES	4
OTHERS	18

8.0 Fruit and Vegetable Preservation Methods

For the preservation and processing of fruits and vegetables, a number of methods are in vogue

1. PHYSICAL METHODS

a) REMOVAL OF HEAT : Refrigeration, Freezing
b) ADDITION OF HEAT : Thermal Processing, canning, bottling, aseptic
c) REMOVAL OF WATER : Drying, dehydration, Concentration
d) IRRADIATION : UV or Ionizing radiation's -Potato and Onion sprout inhibition

2. CHEMICAL METHODS

a) ADDITION OF ACIDS : ADDITION OF ACIDS
Preservation of Pickles
Preservation of chutneys
Vinegar or Lactic acid

b) SALTING AND BRINING : Pickles
c) SUGAR : Preserves, candies, jams, jellies

d) CHEMICAL PRESERVATION : sulphur dioxide, benzoic acid and their salts

3. **FERMENTATION** : Alcoholic, Lactic, acetic-Wines, apple cider, vinegar, sauerkraut.

Combination of one or more technologies always results in product with high acceptability both in domestic and International market.