Consortium for Educational Communication

Module on

Processing of Vegetables

By

Sabeera Muzzaffar

Assistant Professor,

Department of Food Science and Technology,

University of Kashmir,

Srinagar, 190 006

Processing of vegetables

Vegetables are nutritious and one of the excellent sources of vitamins and minerals, apart being laden with riches of dietary fibre. Since times immemorial they had been important part of human diet but over some decades their consumption has increased significantly among the health conscious masses due to their role in prevention of many Non Communicable Diseases (NCD's) like Cardiovascular Diseases (CVD's) and cancer of gut. They are also an important constituent of balanced diet, thus ensuring nutritional security. They are often referred as *"Protective Foods"* by the role they play in preventing many diseases and improving digestion (as vegetables have high digestibility coefficient).

Processing the vegetables to preserve them has been taught to man by the nature. Low temperature prevailing in the frigid regions of the world helped the humans to extend the shelf life of perishable foods. Even in the tropical areas of the world people used the sun to dry out perishable foods both of plant and animal origin. In most of the cases, low and high temperatures were the principal agents used to preserve many foods. Although, technically advanced in its application, the principles used for preserving perishable food are the same, even today. Various techniques for preserving vegetables include dehydration, canning, fermenting, etc. In the recent times many advances have been made in this sector to provide ready to eat and ready to make like foods. As a result we can expect food service industry to grow manifolds in coming future and perhaps be the largest industry in the world.

Owing to the perishable nature of vegetables, weak infrastructure at farm level, insufficient demand at times and poor transportation, the grower sustains substantial losses. The loss is considerable, during the postharvest glut, thus compelling the grower to feed the produce to cattle or allowing it to rot. Processing vegetables intends to supply safe, nutritious, wholesome and acceptable food to consumers all round the year. Moreover, it aims at earning foreign exchange by exporting semi-processed (minimally processed) or finished products like sauces and pickles. The processing of vegetables can help to;

1. Diversify economy.
2. Generate rural and urban employment.

3. Reduce postharvest losses.
4. Alleviate nutritional stress of locals through consumption of their own produce in off season.
5. Generate income for both young and old.
6. Develop value added products.

Flowchart showing different use of vegetables in processing

Vegetables

Diced/Sliced ***Pulped***

Bottle ***Dried*** ***Salted*** ***Sauces*** ***Juices***

Canned ***Chutney***

Pickled

Processing criteria

Certain factors which determine whether a particular vegetable should be processed or not are:

1. Need of a particular vegetable in processed form.
2. Capacity of raw material to withstand processing.
3. Uninterrupted supply of the raw material.

A particular variety of vegetable which can remain fresh for longer time may not require processing, like wise high processing temperature and pressure may cause undesirable flavour and colour change of certain vegetable after processing and a processing unit needs large, regular supplies of raw material and cannot go successful on seasonal gluts.

Varietal influence

A vegetable processor must appreciate the substantial differences that cultivars of a given vegetable possess. Varietal differences further extend into suitability for processing methods like canning, freezing, pickling or dehydration. For example, a variety of peas that is suitable for canning may be quite unsatisfactory for freezing and varieties of potatoes that are preferred for freezing may be less satisfactory for drying or potato chips manufacture. This should be expected since different varieties of a given vegetable will vary somewhat in cellular structure, chemical composition and biological activity of their enzyme system.

Harvesting criteria

There is a time during maturity of a vegetable when it is at its peak quality from the stand point of colour, texture and flavour. This peak quality is quick in passing and may last only a day. Harvesting and processing of several vegetables, including tomatoes and peas are rigidly scheduled to capture this peak quality.

Pre-processing operations

Vegetables can be processed in different ways and the operations involved in the processing depend on the type of vegetable and the method to be used

Washing

The main purpose of washing a vegetable before processing is not only to remove field soil and surface micro-organisms but also to remove fungicides, insecticides and other pesticides. Washing water contains detergents or other sanitizers that can essentially completely remove these residues.

The equipment used, will depend upon the size, shape and fragility of the particular kind of vegetable like for example floatation cleaner for peas and other small vegetables.

Sorting and grading

This step covers two separate operations:

a) Removal of non-standard vegetables and possible foreign bodies after washing;

b) Quality grading based on varietal, dimensional, sensory and maturity stage criteria.

Skin Removal/peeling

Some vegetables require skin removal before they can be processed further. This can be done mechanically, chemically and thermally.

Vegetables like potatoes and root vegetables can be peeled mechanically with abrasive devices and chemicals like hot alkaline solution of lye of about 0.5-3 % at 93 ° C for 0.5-3 min can prove effective in skin removal of soft skinned vegetables like tomatoes. The vegetables with loosened skins are then conveyed under high velocity jets of water which wash away the skins and residual lye. In order to avoid enzymatic browning, this chemical peeling is followed by a short boiling in water or an immersion in diluted citric acid solutions. Vegetables with thick skins such as beets, potatoes, carrots and sweet potatoes may be peeled with steam at 10 atm pressure as they pass through cylindrical vessels. This will soften the skin and the underlying tissue and when the pressure is suddenly released, steam under the skin expands and causes the skin to puff and crack. The skins are then washed away with jets of water at high pressure (12 atm). The table below shows the average losses caused by different peeling methods used.

Table 1. Losses caused by peeling vegetables (%)

Vegetable	Peeling method		
	Manual	Mechanical	Chemical

Potatoes	15-19	18-28	-
Carrot	13-15	16-18	08-10
Beets	14-16	13-15	09-10

Blanching

Blanching is the special heat treatment given to inactivate enzymes. It should not be indiscriminate, where too little becomes ineffective and too much damages the vegetables by excessive cooking, especially where the fresh character of the vegetable is subsequently to be preserved by processing. The heat treatment applied will depend upon

- the specificity of vegetables;
- the objectives that are followed;
- the subsequent processing / preservation methods.

The purpose of blanching is to inactivate enzymes and the most heat resistant enzymes in vegetables are catalase and peroxidase. If both of them are destroyed then the other significant enzymes in vegetables are also considered inactivated. Sensitive chemical tests have been developed to detect the amounts of these enzymes that might survive a blanching treatment and the necessary time to destroy these indicator enzymes (catalase and peroxidase) in different vegetables has accordingly been devised. Because of the differences arising in vegetables with respect to size, shape, heat conductivity and the natural levels of their enzymes, blanching treatments have to be established on an experimental basis. Therefore small vegetables/pieces can be adequately blanched in a minute or two however large vegetables/ pieces might take more.

Blanching as a unit operation is a short duration heating in water or steam at the temperature of about 100° C or below. Steam heat treatment can also be applied instead of water blanching as a preliminary step before freezing or drying, as long as the preservation method is only used for enzyme inactivation and not to modify consistency. Cooling of vegetables after water or steam blanching is performed to avoid excessive tissues softening and is done immediately after these operations. Do not cool them to room temperature. Natural cooling is not recommended because it is too long and generates significant losses in vitamin C and other valuable hydro-soluble substances (mineral salts, vitamins, sugars, etc.). In order to avoid this loss, the temperature of cooling water should be as low as possible. Cooling in water can be achieved either by sprays or by immersion, but in either of the situations the vegetables have to reach a temperature value under 37 °C as early as possible. Drain the vegetables by pouring them directly onto the drying tray held over the sink. Wipe the excess water from underneath the tray and arrange the vegetables in a single layer. Then place the tray immediately in the dehydrator or oven. The heat left in the vegetables from blanching will cause the drying process to begin more quickly. Watch the vegetables closely at the end of the drying period as they dry much more quickly at the end and could scorch.

Table 2. Blanching parameters for some vegetables

Vegetable	Temperature (°C)	Time (min)
Peas	85-90	2-7
Beans	90-95	2-5
Cauliflower	Boiling	2
Carrot	90	3-5
Chillies	90	3

Processing operations

Different processes are employed for processing vegetables, like canning, drying or dehydration,etc.

Drying/Dehydration of vegetables

Drying is probably the oldest method of food preservation known and practiced by mankind. Drying brings about substantial reduction in weight and volume thus minimising packing, storage and transportation costs and also enables storability of the product under ambient temperatures which is especially important for developing countries. The upsurge in the energy costs worldwide has promoted drying foodstuffs over the past decade.

In order to assure products of high quality at a reasonable cost, dehydration must occur fairly rapidly. Four main factors affect the rate and total drying time:

- particle size and geometry of the food to be dried;
- geometrical arrangement of the food stuff in relation to heat transfer medium (drying air);
- physical properties of drying medium/ environment, like air velocity, humidity, temperature, etc;
- characteristics of the drying equipment.

The best time to process the vegetables is when there is a surplus of it and it is difficult to transport it fresh to distant markets. Sun and solar drying of vegetables is a cheap method of preservation because it uses the natural source of heat i.e., sunlight. This method can be used on a commercial scale as well as at village level provided that the climate is hot, relatively dry and free of rainfall during and immediately after the normal harvesting period. The vegetables should be of good quality and as it would need to be if it was going to be used fresh. Poor quality produce cannot be used for natural drying. Also, avoid drying strong-smelling vegetables like onion and garlic, with other food because their flavours will blend. There is an additional step to the process of drying green beans which produces a product more similar to canned green beans. After the green beans have been blanched, place them in a single layer in a freezer for 30 to 40 minutes. Then start the drying process.

Drying methods

Several types of dryers and drying methods, suited to meet a particular situation, are commercially used to remove moisture from a wide variety of food products including vegetables. The three basic types of drying process:

- sun drying and solar drying;
- atmospheric drying including batch (kiln, tower and cabinet

dryers) and continuous (tunnel, belt, belt-trough, fluidised bed, explosion puff, foam-mat, spray, drum and microwave);

- sub-atmospheric dehydration (vacuum shelf/belt/drum and freeze dryers).

Sun drying and atmospheric dehydration are used to dry certain vegetables whereas continuous processes like tunnel, belt trough, fluidised bed and foam-mat drying are used for most of the vegetables. Factors which determine the selection of a particular dryer/ drying method are:

- form of raw material and its properties;
- desired physical form and characteristics of dried product;
- necessary operating conditions;
- unit operation costs.

Determining Dryness

Determining dryness of Vegetables is very important. Vegetables should be dried until they are brittle or "crisp". At this stage, they should contain about less than 10 percent moisture.

Packing and storage

Dried foods are susceptible to insect contamination and moisture re-absorption and must be properly packaged and stored. First, cool the dried food completely as packing warm food will cause sweating, which could provide enough moisture for mould to grow. Packing foods into clean, dry, insect-proof containers as tightly as possible without crushing will help retain quality of dried food. Glass jars, aluminium laminated pouches, metal cans or boxes with tightly fitted lids or moisture and vapour resistant freezer cartons make good containers for storing dried foods.

Dried vegetables should be stored in cool, dry and dark areas. Recommended storage periods for dried foods range from four months to one year. As food quality is affected by heat, the storage temperature helps determine the length of storage; the higher the temperature, the shorter the storage time. Vegetables have about half the shelf-life of fruits, and can generally be stored for six months at 15 °C or three months at 26 °C. Storage temperature helps reduce or inhibit the speed of all physico-chemical, biochemical and microbiological processes, and thus prolongs storage period. Lower storage temperature (0-10° C) help maintain taste, colour and water rehydration ratio and also, to some extent, vitamin C. The moisture content of dried vegetables is not constant because of their hygroscopicity and is always in equilibrium with relative humidity of air in storage rooms. Technical solutions for maintaining low moisture in dehydrated products are:

- storage in stores with air relative humidity below 78%;
- using packages that are impermeable to moisture. The most efficient packages are tin boxes or drums (mainly for long term storage periods); plastic laminated, aluminium laminated pouches (mainly for small packages).

Table 3. Suitability of vegetables for drying

Vegetable	**Suitability**
Asparagus	Fair
Beans	Good
Beets	Fair
Brinjal	Fair
Carrot	Good
Cabbage	Fair
Cauliflower	Poor
Chillies	Good
Garlic	Good
Kale	Poor
Knol khol	Fair
Mushrooms	Good
Onion	Excellent
Peas	Good
Potato	Good
Pumpkin	Good
Radish	Not recommended
Spinach	Poor

Tomatoes	Good
Turnip	Good

Dried vegetable can also be made into powder. This technology has been developed in recent years with applications mainly for potatoes (flour, flakes, granulated), carrots (powder) and red tomatoes (powder). In order to obtain these finished products there are two processes:

- drying of vegetables down to a final water content below 4% followed by grinding, sieving and packing of products;
- vegetables are boiled and then sieved to be made purées which are then dried on heated surfaces (under vacuum preferably) or by spraying in hot air.

Modern solutions are oriented not only to maintain product moisture during storage but also reduce this parameter by the use of desiccants. With desiccants, product moisture can be reduced to even below 4%, and this inhibits or reduces the biochemical and microbiological processes during storage. Calcium oxide is the most commonly used desiccant. Granulated calcium oxide is introduced in small bags from a material which is permeable to water vapour but which does not permit the desiccant to escape into products.

Another factor that can deteriorate dried/dehydrated vegetables is atmospheric oxygen through the oxidative phenomena that it produces. In order to eliminate the action of this agent some packing methods under vacuum or in inert gases like carbon dioxide or nitrogen are used. This is applied mainly for packing dried carrots to avoid beta-carotene oxidation into beta-ionone (foreign smell, discoloration, etc). In order to avoid the action of oxygen ascorbic acid may also be added, which acts as antioxidant (for example in carrot powder).

Vegetable canning

The aim of the canning is to destroy microorganisms in the food and prevent their recontamination. Heat is the most common agent used to destroy microorganisms however, removal of oxygen can be used in conjunction with other methods to prevent the growth of aerobic (oxygen requiring) microorganisms. So it can be said that canning is preservation of foods in the sealed containers which usually implies heat treatment as the principal factor in prevention of spoilage. Mostly canning is done in 'tin cans' which are made of tin coated steel or in glass containers. Also, containers that are partially or completely made of aluminium or of composite material are used for canning.

One of the major differences in the sequence of operations between fruit and vegetable canning is the blanching operation. Most of the fruits are not blanched prior to can filling whereas many of the vegetables undergo this step. Canned vegetables generally require more severe processing than fruits because the vegetables have much lower acidity and contain more heat-resistant soil organisms. Vegetables often contain disagreeable flavours or organic compounds which should be removed before canning; therefore they are usually blanched before being filled into cans. Typical canned products include beans (cut and whole), beets, carrots, peas, spinach and tomatoes. The vegetables may be canned in brine in their natural form or in their curried style using spices, oil, etc as the covering liquid. The type of can, strength of brine, processing conditions and other requirements for different vegetables has been summarised in the table below.

Table 4. Requirements of can type, brine strength, exhaust time and temperature and processing time for common can sizes for canning of non-acid vegetables

Vegetables	**Type of can**	**Strength of brine**	**Exhaust time and temperature**	**Processing time (min) 0.7 kg/cm² steam pressure for different size cans**		
				No 2	**No 2½**	**No 10**
Asparagus	Plain	2.25 % common salt solution	90-100 °C for 7-10 min or till temperature in the centre of can reaches at least 74 °C	10	12	25
Beans	Plain	-do-	-do-	40	40	75
Beet root	Sulphur Resistant	Water or 1.5 % common salt	-do-	30	30	40
Cabbage	Plain	2% common salt solution	-do-	--	40	60
Carrot	Plain	-do-	-do-	20	25	60
Cauliflower	Plain	-do-	-do-	20	20	--
Mushroom	Plain	-do-	-do-	25	25	40
Okra	Plain	2% common salt or tomato sauce	-do-	25	35	--
Peas	Sulphur Resistant	2% common salt + 2.5% sugar	-do-	40	45	60

Potato	Plain	2% common salt	-do-	40	45	--
Turnip	Plain	-do-	-do-	30	35	50

Vegetables used for canning should be absolutely fresh and reasonably free from dirt, soil, etc. 'An hour from the field to can' is accepted ideal. The vegetables used for canning should be tender except tomatoes which should be firm, fully ripe and of deep red colour. Vegetables can be canned in the following ways:

- Canned vegetables in salt brine
- Canned products in tomato concentrated juice
- Canned products in vegetable oil

Technological flowsheet for canning vegetables

RECEPTION

SORTING

WASHING

(in a dilute solution of potassium permanganate or chlorinated water containing upto 150 ppm total chlorine)

CLEANING

CUTTING

BLANCHING

STEAMING

COOLING

FILLING IN RECEPTACLES

(for canning in tomato juice vegetable filling in receptacles are prepared separately as in general canning operation) and (for canning in oil add oil)

PREHEATING

(for canning in tomato juice, tomato juice of not less than 8°B and above 70°C is added)

HERMATIC SEALING

STERILIZATION

COOLING

TESTING FOT DEFECTS

LABELLING

STORAGE

Some of the important considerations that should be looked for during canning are

- Filling in the can be done manually or mechanically with a filling capacity of about 60% by weight of can. Also, the brine concentration may differ slightly with the nature of vegetable and generally ranges from 1.5 to 2.25 % common salt solution. In some cases like peas, small quantity of sugar (2.5%) is also added to the brine. The objective of filling liquid in the cans is to improve taste and fill up the inter spaces between the vegetable pieces so as to facilitate the heat transfer and processing of cans. The brine should be added at a temperature of 80-82 °C and suitable head space should be left so that when the closing end is fitted the space left inside ranges from 0.3- 0.5 cm.
- Since vegetables (except acidic ones like tomato and rhubarb) are generally non acidic with pH above 4.5, they are processed at temperature of about 115-121 °C.
- After processing cans are cooled quickly to prevent overcooking and stack burning. Cooling has sterilizing effect by giving thermal shock to thermophilic microorganisms. It is worth mentioning here that 61% of microorganisms may be killed during processing at 121 °C and 39% during cooling. If processing is carried out at 116 °C, 88% microorganisms are killed during heating and 12% are killed during cooling, showing that higher the processing temperature higher the destruction of microorganisms during cooling.
- In factory, batches of finished cans should be finally tested for leaks or imperfect seals. A non destructive method of using a wax bath of a temperature of about 115.5 °C is used to test the leakage defects among cans apart from destructive method of tapping the can with the help of short steel rod and using a vacuum gauge where the cans showing a vacuum of less than 8 inches of Hg are disqualified.

Aseptic canning is the latest development in canning. It actually is a high temperature short time (HTST) sterilization process. It combines flash sterilization and cooling with aseptic methods of packaging for fluid and semi-fluid products, thus eliminating the retorting and subsequent cooling phases. Aseptic canning is used commercially for bulk packing of products. It has many advantages over conventional canning but is a high cost technology and requires different infrastructure from conventional canning, however the high installation cost may be compromised with the high quality of end product resulting in returns.