Value Addition of Vegetable Crops

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Foreward

In the global scenario, vegetables play a significant role in nutritional and food security. Recently, farmers have shifted the traditional cereal crops to vegetable farming due to high yield, short duration, intensive cropping system, high income and employment generation. Vegetable production is increasing faster than the population and consequently increasing the market surplus and more pressure on post-harvest technologies for vegetables. Further, inadequate storage, transport, handling and processing has led to unacceptable level of wastage and value loss. The magnitude of these losses is 6-18% in fruits and vegetables. Value addition is the easiest way to reduce these losses.

In India, value addition is limited to pickles, chutneys, preserves and candies at cottage level, which is highly decentralized and large units are located at small scale with unskilled labours. However, value addition in fruits and vegetable sector is expected to increase from 8 to 20% by 2025. Fruits and vegetable processing sector is very important for overall growth in India as this sector ensures employment to skilled and unskilled labours.

Due to change in life styles, changing demography at work place and reduced time available for cooking, the demand for high quality processed vegetables are increasing. The demand for ready-to-eat, easy-to-cook vegetables is increasing. Processed vegetables are very popular as it saves time, labour and having extended shelf life. In this context, low cost vegetable processing and value addition is very important to minimize huge post-harvest losses to a greater extent for nutritional security of large section of population.

I hope that compiled information in the bulletin would be useful to researchers, students, teachers, extension workers and entrepreneurs involved in processing and value addition of vegetable crops.

(B. Singh)
The vegetable production in India is largely produced by small and marginal farmers from small scale subsistence level farming systems. Most of the vegetables, except potato and onion are not stored for long duration due to non-availability of simple and cost effective storage systems. Cold chain management facilities of horticultural produce is also negligible in number as a result large quantities of vegetables perish leading to huge post-harvest losses which ultimately affects the livelihood of poor farmer’s family.

Vegetables play an important significant role in human nutrition for not only providing essential nutrients but also providing compounds related to health promotion and disease prevention. Vegetables, being the cheapest source of vitamins, minerals, are the high valued source of nutrition to the poor family. Vegetables also control many life style diseases such as cardiovascular, cancer, renal and gastric diseases to the greater extent.

Under Indian scenario, vegetable processing is restricted mainly on small scale with processing capacities of 250 tons per annum as against the same level of processing in one day by Multi National Companies. Furthermore, there has been gross negligence on quality of processed vegetables in terms of hygiene due to employment of many unskilled labours in fruits and vegetable processing operations.

Fruits and vegetable processing sector is very important as it ensures employment to large section of unemployed youths along with it prevents the huge post-harvest losses to meet the nutritional and food security of the growing population. In view of migration of rural population to urban areas, the demand of processed vegetables is increasing.

Low cost processing technologies of vegetables with good aesthetic values are very important to cater the demand of urban population. Consumers can be attracted to these low cost processing technologies for serving the needs of offseason vegetables. Furthermore, consumers in cities have very little time to cook vegetables daily and cater the nutritional and sensory perception of vegetables. The demand of convenience form of vegetables in form of easy-to-cook, ready-to-eat vegetables would increase with time.

Keeping of above facts in view, this bulletin has been prepared and compiled information in terms of research work at IIVR, Varanasi will be of immense help to students, researchers, extension workers and entrepreneurs.

Authors
Introduction

Vegetables are an important nutritional requirement of human beings as vegetables not only cater the taste of our daily foods but also supply vitamins, minerals and disease preventing phytochemicals. Vegetable production is seasonal in nature as a result the availability of vegetables is confined to 3-4 months a year. It is therefore, necessary to make them available for consumption throughout the year in the form of processed or preserved form.

India is second largest producer of vegetables in the world with annual estimated production of 162 million tonnes from an area of 9.2 million hectares having productivity of 17.3 tonnes/hectare. However, due to poor post-harvest management facility and non-availability of adequate low cost cold chain facilities, large quantities of vegetables perish accounting to the loss of Rs. 500 billion annually.

In view of increase in literacy, awareness and income, the demand of processed vegetables is increasing. Fruits and vegetable processing sector is very important for overall growth and increase in Indian economy. Fruits and vegetable processing sector is almost equally divided between organised and unorganised sector as organised sector is holding 48 per cent of share. The products like juices and concentrate preserved in tetra packs are largely manufactured by the organised sector. However, unorganised sector is concentrating on traditional processed products like pickles, sauces, candy and preserves. The Government also expects the processing sector to grow from current 10% in 2010 to grow to 25% by 2025. Domestic consumption of processed fruit and vegetable products is low, indicating potential for growth, through increased penetration of the domestic market.

There is a big challenge to the post-harvest scientists and entrepreneurs to create the domestic demand of processed vegetable products in large middle income families of our societies. Low cost vegetable processing technologies coupled with maintenance of aesthetic and sensory quality can create demand of processed vegetables in domestic markets. The supply of processed vegetables should be ensured during off season production.

The present Bulletin deals with safe edible coating in the form of shellac coating in vegetables for increasing the shelf life, simple low cost steeping preservation with hurdle concept for increasing the shelf life of vegetables, intermediate moisture leafy vegetables, low cost drying, convenience processed vegetables, pickle and fermented vegetables and sweets from vegetables.
Shellac coating for increasing the shelf life of vegetables

Shellac resin is secreted by the insect (*Laccifer lacca*) found in India. Shellac being composed of aleuritic and shelloic acids, is compatible with waxes and gives coated products a high glossy appearance. This compound is permitted as an indirect food additive but is nevertheless commonly used in coatings for fresh fruits and candies where the coated surface is consumed. It is absolutely safe for coating in fresh fruits and vegetables.

**Shellac coating of Capsicum (Capsicum annum L.)**

**Nutritional and Health benefits**
- Rich sources of vitamin C, vitamin A, antioxidant flavonoid such as lutein, zeaxanthin and crytoxanthin
- Antibacterial, anticarcinogenic, analgesic and antidiabetic properties
- Reduction of triglycerides cholesterol level after regular consumption

**Flow diagram for shellac coating in Capsicum**

```
Dewaxed and bleached Shellac (1g) ↓
  Addition of 20 ml of 0.2% sodium hydroxide ↓
  Heat treatment and addition of 0.6% ammonia in hot condition ↓
  Addition of 3% polyvinyl alcohol with 1% tri ethanol amine ↓
  Cooling to room temperature and addition of 0.5% sodium alginate ↓
Coating on the surface of capsicum with the help of sponge or spraying followed by surface drying and storage at 10°C
```

**Usage:** Capsicum is washed thoroughly in running water before consumption.

**Quality attributes**
- Shelf life extension of 30-35 days after storage at 10°C
- Decrease in ascorbic acid content from 102 mg/100g to 70 mg/100g after 35 days of storage at 10°C
- Decrease in green colour in terms of a value from -12.1 to -8.1 after 35 days of storage at 10°C
- Decrease in hardness in terms of force 4.02N to 2.8N during storage
- Overall sensory acceptability score of 7.5 on 9 – point Hedonic scale
Shellac coating of Pointed gourd
*(Trichosanthes dioica)*

**Nutritional and Health benefits**
- Rich sources of carbohydrates, vitamin A, vitamin C, vitamin B1, vitamin B6, etc.
- Good sources of minerals such as calcium, phosphorus, potassium, magnesium, sulphur and chlorine, etc.
- Good for skin and hair growth
- Acts as blood purifier and skin texture clarifier
- Helpful in reducing gastrointestinal diseases, role in salivary tubule activation and aids in anorexia

**Flow diagram for shellac coating in Pointed gourd**

1. Dewaxed and bleached Shellac (1g)
2. Addition of 20 ml of 0.2% sodium hydroxide
3. Heat treatment and addition of 0.6% ammonia in hot condition
4. Addition of 3% polyvinyl alcohol with 1% tri ethanol amine
5. Cooling to room temperature and addition of 0.5% sodium alginate
6. Coating on the surface of pointed gourd with the help of sponge or spraying followed by surface drying and storage at 10°C

**Usage:** Pointed gourd is washed thoroughly in running water before consumption.

**Quality attributes**
- Shelf life extension of 15 days after storage at 10°C
- Increase in physiological loss in weight to 8.5% after 15 days of storage at 10°C
- Increase in total soluble solids from 3.85% to 5.8% after 15 days of storage at 10°C
- Decrease in ascorbic acid (40-44%) after 15 days of storage at 10°C
Shellac coating of Eggplant (Solanum melongena L.)

**Nutritional and Health benefits**
- Rich sources of various vitamins such as vitamin B1, vitamin B2, vitamin B6, vitamin C and fairly balanced amount of minerals
- Fairly rich sources of bioactive compounds such as phenolics and flavonoids
- Suppress the development of blood vessels required for tumor growth metastasis
- Significant reduction of inflammation after regular consumption

**Flow diagram for shellac coating in Eggplant**

```
Dewaxed and bleached Shellac (1g) ↓
Addition of 20 ml of 0.2% sodium hydroxide ↓
Heat treatment and addition of 0.6% ammonia in hot condition ↓
Addition of 3% polyvinyl alcohol with 1% triethanol amine ↓
Cooling to room temperature and addition of 0.5% sodium alginate ↓
Coating on the surface of eggplant with the help of sponge or spraying followed by surface drying and storage at room temperature (20-22°C)
```

**Usage:** Eggplant is washed thoroughly in running water before consumption.

**Quality attributes**
- Shelf life extension of 7 days at ambient storage temperature (20-22°C)
- Increase in physiological loss in weight from 6.0 – 25.7% after 7 days of storage
- Increase in total solids from 8.5-11.9% during storage
- Decrease in red colour intensity in terms of a value from 13.9 to 10.3 during storage
- Decrease in texture from 89.24 N to 55.7N during storage
- Decrease in antioxidant activity from 389.7 to 182.8 μM gallic acid / g
Shellac coating of Carrot (*Daucus carota*)

**Nutritional and Health benefits**

- Rich sources of β-carotene, vitamin A and vitamin B complex, folic, thiamine, pantothenic acid, etc.
- Fairly good sources of minerals such as calcium, magnesium, phosphorus, zinc, manganese, selenium, iron, etc.
- Rich sources of antioxidant poly acetylene antioxidant such as lutein, zeaxanthin and falcarinol responsible for destruction of precancerous cells in tumors.

**Flow diagram for shellac coating in Carrot**

- Dewaxed and bleached Shellac (1g)
  - Addition of 20 ml of 0.2% sodium hydroxide
  - Heat treatment and addition of 0.6% ammonia in hot condition
  - Addition of 3% polyvinyl alcohol with 1% tri ethanol amine
  - Cooling to room temperature and addition of 0.5% sodium alginate
  - Coating on the surface of carrot with the help of sponge or spraying followed by surface drying and storage at 10°C

**Usage:** Carrot is washed thoroughly in running water before consumption.

**Quality attributes**

- Overall sensory acceptability score of 7.5 on 9-point Hedonic scale after 20 days of storage at 10°C
- Physiological loss in weight increased from 2.64% to 14.8% during storage
- Total solids increased from 9.67% to 12.4% during storage
- Red colour in terms of a value increased from 4.38 to 6.67 during storage
- Antioxidant activity in terms of FRAP decreased from 7.18 to 5.96 µM/g
Steeping preservation of vegetables with hurdle technology

The retention of sensory and nutritional quality in vegetables is the biggest challenge to the processors for the benefit of consumers. It all depends on the application of safer food additives in judicious manner. The combined safer additives acts as hurdles to inhibit the growth of microorganisms and prevent the biochemical reactions leading to breakdown of vegetable constituents such as carbohydrates, proteins and vitamins. The most important hurdles used in vegetable preservation are temperature, water activity, acidity, redox potential, preservatives and competitive microorganisms. The hurdles in vegetables can be kept at optimal range, considering the safety and quality and thus affecting the total quality of foods. A certain set of hurdles is inherent for each stable and safe vegetable which differs in quality and intensity depending on the particular product. But in any case, the hurdles must keep the normal population of microorganisms in the vegetable under control. The microorganisms present in vegetable should not be able to overcome the hurdles present during storage of the product otherwise the vegetable will spoil or even cause food poisoning.

Basic preservation methods imply putting microorganisms in a hostile environment, in order to inhibit their growth or shorten their survival or cause their death. The feasible responses of microorganisms to this hostile environment determine whether they may grow or die. Recent advances have been made by considering the homeostasis, metabolic exhaustion and stress reactions of microorganisms in relation to hurdle technology, as well as by introducing the novel concept of multitarget preservation for a gentle but most effective preservation of hurdle technology foods. Multitarget preservation refers to ambitious goal for a gentle and most effective preservation of foods. It has been reported that that different hurdles in a food might not have an additive effect on microbial stability, but they could act synergistically. A synergistic effect could be achieved if the hurdles in a food hit at the same time different targets such as cell membrane, DNA, enzyme systems, pH, a_w, Eh etc. within the microbial cells and thus disturb the homeostasis of the microorganisms present in several respects. The repair of homeostasis as well as the activation of stress shock proteins becomes more difficult. It is anticipated that the targets in microorganisms of different preservative factors for foods should be elucidated and the hurdles may be grouped in classes according to their targets. A mild and effective preservation of foods is effective if the preservation methods are based on intelligent selection and combination of hurdles taken from different target classes. The synergistic approach is probably not only valid for traditional food preservation procedures but as well for modern processes such as food irradiation, ultra high pressure, pulsed technologies. Multitarget effect is effective in controlling the highly contagious diseases such as tuberculosis and AIDS.

The use of antimicrobials is a common practice for preservation of foods. The incorporation of antimicrobial in a food recipe reflects towards inhibition of spoilage and pathogenic microorganisms which results in the compositional modification of food. The majority of consumers are demanding the natural antimicrobials such as bacteriocins which inhibit the microbial growth.

Bacteriocins are proteinaceous compounds consisting of peptides and amino acids with antimicrobial activity and are synthesized by the ribosomes of the microbial cells. Over the decades, numerous bacteriocins produced by lactic acid bacteria (Lactobacillus, Lactococcus, Enterococcus, Pediococcus and Carnobacterium) have been isolated and characterized as nisin, lactococcins, sakacin, curvatin, carnebacteriocins, pediocins, etc. Bacteriocins gained increased attention because of their potential application as natural antimicrobials in foods to substitute or decrease the addition of other chemical preservatives which are considered hazardous. Among the bacteriocins, nisin is very popular additive in variety of food products such as milk and milk products, fruits and vegetables products and meat based products to control gram positive bacteria.
Steeping preservation of Cauliflower
*(Brassica oleracia var botrytis)*

**Nutritional and Health benefits**
- Rich sources of vitamin C, vitamin K, vitamin E, vitamin A, folate and dietary fibre
- Protection against lung, prostate, breast and chemically induced cancers in cruciferous vegetables rich in glucosinolates
- Rich sources of manganese, phosphorus and magnesium

**Flow diagram for steeping preservation of cauliflower**

![Flow diagram](image)

**Usage:** Steeped cauliflower is washed in water and it is used for pickle or curry preparation.

**Quality attributes**
- Overall acceptability score of 8.0 on 9-point Hedonic scale after 8 months of storage
- Maximum decrease in pH of curd pieces from pH 6.3 to 3.68 after 15 days of storage in steeped cauliflower samples with 4% sodium chloride, 1% acetic acid and 350 ppm sulphur dioxide
- Maximum decrease in hardness value of curd pieces (15.20N-10.12N) during 120 days of storage with steeped solution of 6% sodium chloride, 2% acetic acid and 350 ppm sulphur dioxide
- Decrease in extent of browning, ascorbic acid and total carotenoids content in steeped cauliflower samples of 2-6% sodium chloride, 1-2% acetic acid and 350 ppm sulphur dioxide, respectively during storage
Steeping preservation of Carrot (*Daucus carota*)

**Nutritional and Health benefits**
- Major source of β-carotene providing 17% of the total vitamin A consumption along with rich sources of vitamin C, vitamin K, thiamine, riboflavin, pyridoxine and folates
- Good sources of lipophilic antioxidants like lycopene and lutein
- Significant role in controlling diabetes due to low glycaemic index
- Cholesterol lowering effect due to increased level of dietary fibre

**Flow diagram for steeping preservation of carrot**

```
Carrot
↓
Washing and trimming
↓
Slicing / Cutting
↓
Steeping into 25% sugar solution, 0.4% citric acid, 400 ppm benzoic acid and 400 ppm sulphur dioxide
↓
Storage of carrot slices in glass bottles with steeping solution for 6-8 months at 25-30°C
```

**Usage:** Steeped carrot is washed in water and it is consumed for salad or for the preparation of carrot based *halwa*

**Quality attributes**
- Overall acceptability score of 8.02 on 9-point Hedonic scale after 6 months of storage at ambient temperature
- Reduction of reducing sugar, total carotenoids and ascorbic acid to the level of 30-26.45%, 44-48% and 48-58%, respectively during storage
- Suitable for carrot based *halwa* even after 6 months of ambient storage
Steeping preservation of Pointed gourd
(Trichosanthes dioica)

Nutritional and Health benefits
- Most nutritive cucurbit vegetable in Indian market during summer and rainy season
- Rich sources of protein and vitamin A content
- Significant effect in lowering blood sugar, serum triglycerides, cardiotonic and anthelmintic properties
- Easily digestible and diuretic nature

Flow diagram for steeping preservation of pointed gourd

Usage: Steeped pointed gourd is washed in water and it is used for pickle or curry preparation.

Quality attributes
- Overall acceptability score of 7.0 on 9-point Hedonic scale after 4 months of storage
- Maximum decrease in pH from 6.94 to 3.84 after 4 months of storage
- Maximum decrease in green colour in terms of a value (-9.94 to -6.67) after 4 months of storage
Steeping preservation of French beans (Phaseolus vulgaris)

Nutritional and Health benefits
- Low in calories (31 calories per 100 g), rich sources of dietary fibre, excellent balance of essential amino acids and rich source of dietary fibre
- Good sources of vitamin A and health promoting flavonoid polyphenolic antioxidants such as lutein, zeaxanthin and β-carotene in good amounts
- Rich sources of pyridoxine (vitamin B6), thiamine and vitamin C
- Presence of good amounts of minerals like iron, calcium, magnesium, manganese and potassium essential for body metabolism

Flow diagram for steeping preservation of french bean

Usage: Steeped french bean is washed in water and it is used for pickle or curry preparation.

Quality attributes
- Decrease in pH from 6.3 to 4.8 during storage
- Decrease in green colour in terms of a value from -3.2 to -2.4 during storage
- Decrease in hardness value from 4.3N to 2.8N during storage
Steeping preservation of Bitter gourd 
*(Momordica charantia)* slices

**Nutritional and Health benefits**
- Excellent remedy for diabetic patients due to hypoglycaemic effect
- Ideal treatment for blood disorders due to blood purifying properties
- Effective treatment for preventing constipation, secretion of more bile juice from liver and strengthening immune system
- Remedy for skin diseases, psoriasis, skin infections such as eczema, stimulation of energy and stamina in people suffering from chronic fatigue
- Rich sources of mineral such as calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper and manganese
- Potential sources of vitamins such as vitamin A, vitamin C, thiamine, riboflavin, niacin, vitamin B6, folate, pantothenic acid, etc.

**Flow diagram for steeping preservation of bitter gourd slices**

```
Bitter gourd
↓
Sorting, washing and cutting of stalk
↓
Cutting into thin slices of 0.25-0.3 cm
↓
Blanching in boiling water for 15-20 sec containing 0.1% magnesium oxide followed by steeping into 1% sodium sulphite solution for 10 min
↓
Steeping into 2.5% sodium chloride solution, 1% acetic acid, 350 ppm sulphur dioxide and 350 ppm benzoic acid
↓
Storage of bitter gourd slices in glass bottles with steeping solution for 4-5 months at 25-30° C
```

**Usage:** Steeped bitter gourd slices is washed in water and it is used for pickle or curry preparation.

**Quality attributes**
- Good sensory overall acceptability score of 7.5 on 9-point Hedonic scale after 5 months of ambient storage
- Decrease in ascorbic acid to 18-20 mg/100g after storage
- Decrease in hardness value of bitter gourd slices from 3.8N -1.5 N after storage
- Decrease in green colour in terms of a value from -5.5 to -3.5 after storage
Steeping preservation of Onion
(*Allium cepa*) with hurdle concept

**Nutritional and Health attributes**

- Excellent sources of vitamin C, flavonoids and phytochemicals thus encouraging immune system
- Acts as powerful anticarcinogenic compounds due to presence of quercetin, against cancer cells of breast, colon, prostate, ovarian and lung tumors
- Soluble dietary fibre, oligofructose as probiotic effect in increasing bacterial population in intestine
- Regulation of blood sugar due to chromium in onion

**Flow diagram for steeping preservation of onion**

```
Onion bulb
  ↓
Peeling
  ↓
Washing
  ↓
Steeping of onion bulb in 2% sodium chloride solution, acetic acid steeping (pH 2.5-2.75), 300 ppm sulphur dioxide for 7 days followed by heat treatment at 100°C for 3-5 min
  ↓
Storage of onion bulb in steeping solution for 60-75 days at ambient storage (25-30°C)
```

**Usage:** Steeped onion after washing is preferred as salad in food

**Quality attributes**

- Significant reduction in microbial load (98-99%) after acetic acid steeping (pH 2.5-2.75) and 2% sodium chloride solution
- Overall acceptability score of 7.5-8.0 on 9-point Hedonic scale after 75 days of ambient storage
- Reduction in D value (1.58 min-1.0 min) in onion bulb at pH 2.5-2.75 after 2% sodium chloride steeping solution, 300 ppm sulphur dioxide and heat treatment at 100°C for 3 min
Preservation of Onion (*Allium cepa*) paste with hurdle concept

Nutritional and Health benefits

- Improvement in immunity response due to presence of phytochemicals in onion
- Presence of high chromium level in regulating blood sugar
- Reduction of inflammation and heart infections due to regular consumption of onion
- Production of high density lipoprotein due to regular intake of fresh onions in diet
- Significant effect on prevention of cancer due to quercetin

Flow diagram for preservation of onion paste

Usage: Onion paste is used for vegetable-based curry preparation.

Quality attributes

- Significant reduction in microbial count (95-98%) of onion paste with increase in heat treatment at 100°C for 3-5 min
- Maximum decrease (1.15 min – 0.69 min) in D value of onion paste with addition of 2% table salt, pH 2.75, 375 ppm sulphur dioxide and heat treatment at 100°C for 5 min
- Maximum overall acceptability score of 7.5 on 9-point Hedonic scale after ambient storage for 60 days
Intermediate Moisture Leafy Vegetables

Green leafy vegetables are store house of bioactive nutrients and provide high amounts of micro-minerals which play vital roles in nutrient metabolism and retard degenerative diseases. The high dietary fibre in green leafy vegetables helps in regulating the digestive system aiding bowel health and weight management. Several studies have shown that high folate intake from green leafy vegetables may lower the risk of colon polyps by 30 to 40 percent compared to low intake of this vitamin suggesting that diets low in folate may increase the risk of colon cancer.

Leafy vegetables are ideal for weight management as leafy vegetables are typically low in calories and are useful in reducing the risk of cancer and heart disease. Leafy vegetables are low in fat, high in dietary fibre and rich in folic acid, vitamin C, potassium and magnesium, as well as containing a host of phytochemicals, such as lutein, cryptoxanthin, zeaxanthin, and α-carotene which can also be converted into vitamin A and also improve immune function.

Many leafy vegetables are consumed without proper processing especially heat processing. Leafy vegetables are carrier of spoilage pathogenic organisms especially E. coli, Salmonella and Shigella and this can be of considerable public health concerns to the consumers. The consumers prefer many leafy vegetables especially coriander, radish and drumstick as such or with mild heat treatment for salads. Consumers are looking for fresh vegetables for salads in view of many benefits such as antioxidants, neutraceuticals, vitamins and minerals in diet. Various Psychrotropic bacteria such as Listeria monocytogenes and Clostridium botulinum are known to grow at low temperature.

Drying is one of the simplest technologies for reducing the post harvest losses in vegetables. But the quality is adversely affected in terms of sensory and rehydration quality in dried vegetables. The quality of dried vegetables is significantly improved with additive treatment during blanching treatment. However, rehydration of dried vegetables with moisture content less than 1-2% becomes difficult with reference to rheological and sensory qualities. In this regard, drying of vegetables under intermediate moisture range of 15-25% is better alternative for increasing the aesthetic qualities, shelf life and preserving the valuable nutrients for nutritional security.
Intermediate Moisture Amaranth (Amaranthus caudatus) leaves

Nutritional and health benefits of Amaranth leaves
- Good sources of vitamins such as vitamin A, vitamin C and folate and minerals such as calcium, iron, potassium, zinc, copper and manganese
- Rich source of β-carotene, lutein and zeaxanthin
- Helpful in reducing cholesterol level due to high dietary fibre content

Flow diagram for the manufacture of Intermediate moisture amaranth leaves

Usage: Dried amaranth leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation

Quality attributes
- Good overall acceptability score of 8.0 on 9-point Hedonic scale after 50 days of storage at 10-15°C
- Decrease in ascorbic acid from 45.58 mg/100 g to 30.23 mg/100g after 50 days of storage
- Moisture content varied from 18.5-15.75% during storage
Intermediate Moisture Spinach (Beta vulgaris var. bengalensis) leaves

Nutritional and Health benefits
- Potential rich sources of vitamin C, vitamin A, vitamin E, vitamin K, folate, and minerals such as potassium, manganese, magnesium, copper, zinc, etc.
- Role in prevention of constipation, hypertension, onset of early osteoporosis, atherosclerosis, and proper moisture retention in skin
- Strong antioxidant activity thus prevention of cancerous cells of various parts of body and prevention of cataract, age-related macular degeneration due to presence of lutein and zeaxanthin

Flow diagram for the manufacture of Intermediate moisture spinach leaves

Usage: Dried spinach leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation

Quality attributes
- Good overall acceptability score of 7.5 on 9-point Hedonic scale after 50 days of storage at 10-15°C
- Decrease in ascorbic acid to the extent of 45-50% during 50 days of storage
- Increase in moisture content from 16.4-17.3% during storage
**Drying technology in Vegetables**

Drying or dehydration is one of the most effective means to extend the shelf life of perishable fruits and vegetables. The main purpose of dehydration in preserving fruits and vegetables is to remove moisture so that water activity of the dehydrated products is low enough of a less than 0.6 for preventing the spoilage and the growth of pathogenic microorganisms and subsequently to reduce the spoilage reactions. Dehydration is also used in combination with other preservative factors such as initial heating of vegetable in boiling water and salt solution to extend the shelf life of vegetables. Dehydration significantly reduces the cost of transportation and storage due reduced weight and volume of dehydrated vegetables. Unlike fresh vegetables, dehydrated vegetables do not require refrigeration during storage.

Sun drying has been used since ancient times to produce dehydrated vegetables. This method is expensive but the effectiveness of drying depends on bright sunshine and longer drying times. The dried vegetables with sun drying are not widely acceptable due to unhygienic quality.

Another dehydration technique, viz., osmo-air drying is a simple process and has potential advantages for preservation of vegetables for longer duration. The inclusion of osmotic process in conventional dehydration has major objectives of quality improvement and energy savings. This process also resulted in quality improvement in terms of colour, flavour, texture, product stability, nutrient retention and prevention of microbial spoilage during storage. Different factors such as pre-treatment, nature and concentration of osmotic solution, raw material characteristics, stage of maturity, size of slices, duration of osmosis, ratio of slice to brine concentration and agitation influence the quality of dried vegetables. Osmo air-drying has greater potential for drying of large quantities of vegetables with good sensory properties. This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale.

The principle involved during dehydration involves removal of moisture by application of heat under controlled conditions of temperature, humidity and air flow. In this process, single layer of sliced and shredded vegetables after blanching treatment is spread on trays in the dryer. The initial dryer temperature in cabinet or tray dryer is normally adjusted to 60-65°C for 4-5 hrs and afterwards the dryer temperature is reduced to 50-55°C for completion of drying with final moisture content to less than 2%. However, various factors such as composition of vegetables, size, shape and arrangements of vegetables in the tray, temperature and movement of hot air across the trays, heat transfer from vegetable surface such as conductive and convective rate of heat transfer.

Newer innovative drying processes have significantly improved the sensory qualities and retention of nutrients in dried vegetables. The use of additives improves in retaining green colour, ascorbic acid and bioactive compounds in dried vegetables. Drying process also improves the rehydration quality and thus improves the aesthetic quality in dried vegetables. Vegetables during drying process behaves constant and falling drying rate of moisture removal from vegetables. Constant drying rate refers to removal of moisture in proportion to the application of heat. Higher heating temperature initially removes the moisture from faster rate during constant drying rate. However, during the course of drying, the moisture content is reduced to much lower level as a result moisture removal is not proportional to the application of heat to vegetable surface. The reduced level moisture removal refers to falling drying rate in vegetables.

This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale. There is ample scope for cost reduction through the use of solar energy for brine concentration and dehydration process.
Drying of Okra (Abelmoschus esculentus L.)

Nutritional and Health benefits

- Effective prevention of colon cancer and skin discolouration due to presence of phytochemicals such as lutein, indoles, sulforaphane, carotenoids, isoflavones, etc.
- Higher presence of many nutrients including vitamins A, B6, C, iron, fibre, calcium and folic acid
- Stabilization of blood sugar through okra fibre from the intestinal tract
- Lubrication of large intestine due to its bulk laxative qualities of fibre
- Absorption of water and movement of stool in bulk
- Significant role in lowering serum cholesterol and reducing the risk of heart diseases
- Role in healing ulcers and to keep joints limber
- Help in neutralizing acids and temporary protective coating for the digestive tract
- Suitable treatment for lung inflammation, sore throat and irritable bowel syndrome
- Protection of cancer expansion of colorectal cancer and reducing the risk of cataracts
- Highly perishable crop having shelf life of 2-3 days at ambient storage temperature

Flow diagram of drying of okra

Usage: Dried okra is fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

Quality attributes

- Retention of Vitamin C (6-8 mg/100g)
- Rehydration ratio (3-3.5) in boiling water for 4-5 min
- Recovery of dried okra slices (6.5-7.25%)
Osmo-air drying of Bitter gourd

*(Momordica charantia L.)*

**Nutritional and Health benefits**

- Rich sources of vitamin A, B1, B2 and C and also presence of minerals such as calcium, phosphorus, copper and potassium.
- Potential health benefits such as antidotal, antilytic, lyogenic, antipyretic tonic, appetizing, stomachic, antibilious, purgative, antiinflammatory, antiflatulent and higher healing capacity.
- Typical bitter taste with many medicinal values

**Flow diagram of osmo-air drying of bitter gourd**

1. Bitter gourd
2. Washing and cutting into slices (0.25-0.3 cm)
3. Blanching of bitter gourd slices in boiling water containing 0.1% magnesium oxide for 1 min followed by dipping into 1% sodium sulphite solution for 10 min
4. Osmotic diffusion treatment in 4-5% sodium chloride solution at 50-60°C for 60-90 min
5. Drying in cabinet dryer
   - I stage of drying at 60°C for 3-4 hrs
   - II stage of drying at 50-55°C for 8-10 hrs
6. Cooling at room temperature
7. Packaging in polypropylene pouches and storage at room temperature at 20-25°C for 6 months

**Usage:** Dried bitter gourd slices is fried in refined oil along with spices followed by addition of water for rehydration.

**Quality attributes**

- Good overall acceptability sensory score of 7.5 on 9-point Hedonic scale of rehydrated bitter gourd slices during 6 months of storage.
- Vitamin C (20-27 mg/100g)
- Rehydration ratio (5.0-5.8)
- Recovery of dried bitter gourd slices (6.5-7.2%)
Osmo-air drying of Cauliflower
(*Brassica oleracea var botrytis*)

**Nutritional and Health benefits**
- Rich sources of carbohydrates, proteins, dietary fibres, vitamins such as vitamin A (750 IU) and vitamin C (55-60 mg/100g) and rich sources of minerals such as sodium, potassium, magnesium, iron, calcium and phosphorus
- Presence of fairly good amounts of vitamin B complex and proteins in comparison to other leafy vegetables
- Major carotenoids such as lutein, neoxanthin, violaxanthin and β-carotene.
- Presence of good sources of tocopherols and other important bioactive compounds such as glucosinolate, ascorbic acid and phenolics including flavonoids
- Limited shelf life of 3-4 days at room temperature

**Flow diagram of osmo-air drying of cauliflower florets**

```
Cauliflower florets (2.5-3.0 cm)
↓
Washing
↓
Blanching in boiling water for 30-45 sec followed by dipping into 0.2% potassium metabisulphite solution for 10 min
↓
Osmotic diffusion treatment in 4-5% sodium chloride solution at 50-60°C for 45-60 min
↓
Drying in cabinet dryer
I stage of drying at 60°C for 3-4 hrs
↓
II stage of drying at 50-55°C for 8-10 hrs
↓
Cooling at room temperature
↓
Packaging in polypropylene pouches and storage at room temperature at 20-25°C for 6-7 months
```

**Usage**: Dried cauliflower pieces are fried in refined oil along with spices followed by addition of water for rehydration.

**Quality attributes**
- Final moisture content (1-2%)
- Retention of ascorbic acid (16-18 mg/100g) and total carotenoids (1.5-1.75 mg/100g)
- Sensory overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried cauliflower (9.5-10.8%)
Drying of Indian beans (*Dolichus lablab* L.)

**Nutritional and Health benefits**
- Good sources of carbohydrates, protein, cholesterol lowering fibre and free from fat
- Supply of vitamins such as thiamine, riboflavin, niacin, folic acid and vitamin C
- Fairly rich in minerals such as calcium, iron, magnesium, manganese, phosphorus, potassium, zinc, etc.
- Helpful in preventing heart diseases, cancer, obesity and diabetes

**Flow diagram for drying of indian beans**

```
Indian beans
↓
Washing in running water
↓
Cutting into 2.0-2.5 cm size with sharp stainless steel knife
↓
Blanching in boiling water containing 0.1% magnesium oxide for 1-1.5 min followed by dipping into 1% sodium sulphite solution for 10 min
↓
Drying in cabinet dryer
I stage of drying at 60°C for 3-4 hrs
↓
II stage of drying at 50-55°C for 8-10 hrs
↓
Cooling at room temperature
↓
Packaging in polypropylene pouches and storage at room temperature at 20-25°C for 5-6 months
```

**Usage:** Dried Indian bean pieces are fried in refined oil along with spices followed by addition of water for rehydration.

**Quality attributes**
- Sensory overall acceptability score of 7.5 on 9-point Hedonic scale
- Moisture (1.25%) of 1-1.25%
- Vitamin C content (14-17 mg/100g) during storage
- Decrease in green colour (a) value from - 4.56 to -3.94 during storage
- Recovery of dried indian beans pieces (7.5-8.5%)
Osmo-air drying of Carrot (*Daucus carota*)

**Nutritional and Health benefits**

- Rich sources of vitamins, minerals and dietary fibers
- Fairly good source of both hydrophilic as well as lipophilic antioxidants such as β-carotene, α-carotene, lutein and lycopene
- Presence of xanthophyll in yellow carrot as bioactive lutein thus protecting eye from age related macular degeneration and cataract
- Good source of abundant lycopene in red carrot in addition to β-carotene and α-carotene as a functional ingredient preventing prostate cancer and thus scavenging free radicals from body
- Major hydrophilic antioxidants as phenolics, flavonoids and anthocyanin

**Flow diagram of osmo-air drying of carrot slices**

```
Carrot
↓
Grading, washing and cutting into slices (0.2-0.25 cm)
↓
Blanching in 20% sugar solution at 80-85°C for 4-5 min followed by dipping into 0.2% potassium metabisulphite solution for 10 min
↓
Osmotic diffusion of 50-55% sugar solution at 50-55°C for 90 min
↓
Cabinet drying of carrot slices
I stage of drying at 60°C for 3-4 hrs
↓
II stage of drying at 50-55°C for 8-10 hrs
↓
Cooling at room temperature
↓
Storage in air tight plastic containers at 10-15°C for 4-6 months
```

**Usage:** Osmo-air dried carrot slices is directly consumed as sweet meat.

**Quality attributes**

- Overall sensory acceptability score of 8.5 on 9-point Hedonic scale
- Vitamin A content (800-1000 IU)
- Recovery of dried carrot slices (10.5-11.75%)
Osmo-air drying of Ivy gourd (*Coccinia grandis*)

**Nutritional and Health benefits**
- Rich source of β-carotene, a major vitamin A precursor from plant sources
- Good sources of protein and fibre and many important minerals such as calcium, phosphorus, iron, copper and potassium.
- Control of diabetic and mechanism reflected due to suppression the activity of certain enzymes involved in glucose production, such as Glucose 6-phosphatase

**Flow diagram of osmo-air drying of ivy gourd**

Usage: Dried ivy gourd is fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Moisture (1.5-2.0%)
- Ascorbic acid (5.0-6.0 mg/100g)
- Rehydration ratio (3.0-3.5)
- Recovery of dried ivy gourd slices (2.8-3.0%)
**Osmo-air drying of Pointed gourd**

*(Trichosanthes dioica)*

**Nutritional and Health benefits**
- Rich sources of vitamin A, B1, B2 and C and minerals such as calcium, phosphorus, iron, copper and potassium
- Role in purification of blood tissue, enhancement of digestion and thus stimulating the functioning of liver
- Supported evidence of lowering total cholesterol and blood sugar
- Active ingredients for soup, stew, curry, sweet or eaten fried and as meat stuffing
- Limited shelf life of 2 days at ambient storage temperature

**Flow diagram of osmo-air drying of pointed gourd**

1. Pointed gourd
2. Washing and cutting into 0.2-0.25 cm slices
3. Blanching treatment at 100°C for 30 sec in 0.1% magnesium oxide followed by dipping in 1% sodium sulphite solution for 10 min
4. Osmotic diffusion treatment in 4-5% sodium chloride solution at 55-60°C for 1 hr
5. Drying in cabinet dryer at 50-60°C for 8-10 hrs
6. Cooling and packaging in polypropylene pouches and storage at 20-25°C for 6-8 months

**Usage:** Dried pointed gourd is fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Good rehydration ratio of 2.5-3.0 in boiling water for 4 min
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Ascorbic acid (10-12 mg/100g)
- Recovery of dried pointed gourd slices (8.5-9.25%)
Osmo-air drying of Green Chillies
(*Capsicum annuum* L.) powder

**Nutritional and Health benefits**
- Important sources of vitamin C (110 mg/100g), capsaicinoids, a source for pungency
- Presence of capsaicin as main capsaicinoids (69%) present in pericarp and placenta of fruits followed by dihydrocapsaicin (22%), nordihydrocapsaicin (7%), homodihydrocapsaicin (1%) and homocapsaicin (1%)
- Help in digestion by stimulating saliva and gastric juice flow
- Suitable for the treatment of sensory nerve fiber disorders including pain, associated with arthritis and diabetic neuropathy

**Process for the manufacture of green chilli powder**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Green chillies</td>
</tr>
<tr>
<td>2</td>
<td>Washing and cutting uniformly 1.0-1.5 cm size</td>
</tr>
<tr>
<td>3</td>
<td>Blanching in 0.5% magnesium carbonate solution at 100°C for 5 min followed by dipping in 0.75% potassium metabisulphite solution for 10 min</td>
</tr>
<tr>
<td>4</td>
<td>Osmotic diffusion treatment in 4-5% sodium chloride solution at 55-60°C for 90-120 min</td>
</tr>
<tr>
<td>5</td>
<td>Drying in cabinet dryer at 55°C for 8-10 hrs</td>
</tr>
<tr>
<td>6</td>
<td>Blending of chilli flakes and sieving to 25-30 mesh size</td>
</tr>
<tr>
<td>7</td>
<td>Packaging in polypropylene pouches and storage at 20-25°C for 6 months</td>
</tr>
</tbody>
</table>

**Usage**: Green chilli powder can be preferred in place of red chilli powder.

**Quality attributes**
- Retention of 48 mg/100 vitamin C, 1.363 mg/l chlorophyll and 0.4% capsaicin in green chilli powder
- Retention of 80-85% green colour in dried green chilli powder
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried green chilli powder (7.5-8.5%)
Osmo-air drying of Tomato 
(*Lycopersicon esculentum* L.) powder

**Nutritional and health benefits**
- Rich source of lycopene, an antioxidant with immunostimulatory properties
- Good source of ascorbic acid, β-carotene, phenolics such as ferulic, chlorogenic and caffeic acid and vitamin E
- Loss of lycopene during dehydration process
- Less losses of lycopene under osmotic diffusion due to fewer cis-isomers

**Flow diagram for osmo-air drying of tomato powder**

![Flow diagram](image)

**Usage:** Tomato powder can be used in place of tomato in curry preparation.

**Quality attributes**
- Ascorbic acid (8-10 mg/100g)
- Lycopene (3-3.5 mg/100g)
- Rehydration ratio (1.5-2.0)
- Overall acceptability score of 7.5 on 9-point Hedonic scale
- Recovery of dried tomato powder (2.5-3.25%)
Osmo-air drying of Cabbage
(*Brassica oleracea var. capitata*) leaves

**Nutritional and Health benefits**

- Excellent sources of many important minerals such as manganese, calcium, potassium and also fairly good sources of iron, phosphorous, magnesium, sodium, zinc and copper.
- Presence of vitamin C, thiamine, riboflavin, niacin, vitamin B6, fibre, folate and omega-3 fatty acids thus improving the functional quality in cabbage.

**Flow diagram of osmo-air drying of cabbage leaves**

- Cabbage heads
- Washing and cutting into 1-1.5 cm in length with sharp edged stainless steel knife
- Blanching of cabbage shreds in 0.1% magnesium oxide at 100°C for 30 sec followed by dipping into 1% sodium sulphite solution for 10 min
- Drying in cabinet dryer at 50-55°C for 5-7 hrs
- Cooling and packaging in polypropylene pouches for 5-6 months at 20-25°C

**Usage:** Dried cabbage leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**

- Vitamin C (15.5-17.0 mg/100 g) in dried cabbage leaves
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried cabbage leaves (6.8-7.5%)
Drying of Fenugreek (Trigonella foenum-graecum) leaves

**Nutritional and Health benefits**
- Good sources of minerals such as potassium, calcium and iron
- Presence of good dietary fibre enriched with vitamin C and vitamin K
- Fairly good sources of protein and nicotinic acid
- Fosters hair growth, good for the general health and shine of hair

**Flow diagram of drying of fenugreek leaves**

- Fenugreek leaves
- Sorting, grading and removal of field weeds
- Washing thoroughly in water 3-4 times to remove dirt particles
- Blanching in 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 80°C for 30-60 sec
- Drying in cabinet dryer at 55-60°C for 4-5 hrs
- Cooling and packaging in polypropylene pouches and storage for 6-7 months at 20-25°C

**Usage:** Dried fenugreek leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation

**Quality attributes**
- Rehydration ratio (2.5-3.0)
- Overall acceptability score of 8.5 on 9-point Hedonic scale
- Vitamin C (35-40 mg/100g)
- Recovery of dried fenugreek leaves (7.5-9.0%)
Drying of Bathua (Chenopodium album) leaves

**Nutritional and Health benefits**

- Store house of nutrients such as 0.8% fat, 4.3% protein, 2.1% dietary fibre and 90 mg/100 g vitamin C
- Good for functioning of liver, spleen and gall bladder
- Good appetizer and improvement in hemoglobin level

**Flow diagram of drying of Bathua leaves**

Usage: Dried bathua leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**

- Rehydration ratio (1.5-2.0)
- Vitamin C (20-25 mg/100g)
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried bathua leaves (6.8-7.2%)
Drying of Spinach (Beta vulgaris var. bengalensis) leaves

**Nutritional and Health benefits**
- Store house of many phytonutrients that have health promotional and disease prevention properties
- Rich sources of several polyphenolic antioxidants such as lutein, zeaxanthin and \(\beta\)-carotene, and vitamins such as vitamin A, vitamin C
- Presence of many vitamin B complex vitamins like vitamin B6, thiamine, riboflavin, folates and niacin and rich sources of minerals like iron, potassium, magnesium, copper and zinc

**Flow diagram of drying of spinach leaves**

Spinach leaves ↓
Sorting, grading, cleaning of field weed and thoroughly washing 3-4 times in water ↓
Blanching with 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 100°C for 30 sec ↓
Drying in cabinet dryer at 50-55°C for 5-6 hrs ↓
Cooling and packaging in polypropylene pouches and storage for 8-10 months at 20-25°C

**Usage:** Dried spinach leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation

**Quality attributes**
- Rehydration ratio (3.5-4.5)
- Sensory overall acceptability score of 7.5 on 9-point hedonic scale
- Vitamin C content (12-15 mg/100g) in dried spinach leaves
- Recovery of dried spinach leaves (6.5-7.0%)
**Drying of Amaranth (Amaranthus caudatus) leaves**

**Nutritional and Health benefits**
- Rich sources of vitamins such as vitamin A, vitamin C, vitamin D, vitamin E, vitamin K, vitamin B complex and folate
- Fairly good sources of minerals such as calcium, phosphorus, magnesium, potassium, zinc, copper and selenium
- Prevention of inflammation of body such as control of arthritis, gout and kidney diseases
- Rich in high dietary fibre thus controlling high density lipoprotein cholesterol

**Flow diagram of drying of amaranth leaves**

```
Amaranth leaves  ↓
Sorting, grading, cleaning of field weed and thoroughly washing 3-4 times in running water  ↓
Blanching with 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 100°C for 15-20 sec  ↓
Drying in cabinet dryer at 50-55°C for 4-5 hrs  ↓
Cooling and packaging in polypropylene pouches and storage for 8-10 months at 20-25°C
```

**Usage:** Dried amaranth leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Rehydration ratio (4.0 - 4.5)
- Sensory overall acceptability score of 8 on 9-point hedonic scale
- Vitamin C (14-18 mg/100g)
- Recovery of dried amaranth leaves (5.75-6.25%)
Drying of Moringa (Moringa oleifera) leaf powder

Nutritional and Health benefits

- Most widely cultivated species of the Moringaceae family, which are native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan
- Presence of significant quantities of proteins, vitamin A, B and C and minerals such as calcium, iron and phosphorus
- Fairly high amounts of essential amino acid with the right balance, as well as high amounts of minerals and vitamins
- Control of diabetes and hypertension in adults

Flow diagram for drying of moringa leaf powder

Usage: Dried moringa leaf powder can be used as beverage or can be consumed as such. Dried moringa leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

Quality attributes

- Moisture (1%)
- Protein (22-24%)
- Ascorbic acid (12-14mg/100g)
- Retention of green colour (85-90%)
**Drying of Moringa (Moringa oleifera) pod**

**Nutritional and Health benefits**
- Rich sources of proteins, vitamins, minerals and bioactive compounds
- Traditional source of medicines to cure many diseases
- Niaziridin and niazirin, antibacterial fractions isolated from moringa pods as the combination of therapy with drugs and nutrients resulting in reduced drug associated toxicity, reduced cost and duration of chemotherapy

**Flow diagram of drying of moringa pod**

Usage: Dried moringa pod is preferred in soup for increasing the protein content and protein rich soup formulation.

**Quality attributes**
- Moisture content (1%)
- Protein content (14-15%)
Comparative Osmo-air and Osmo-freeze drying of Green pea (*Pisum sativum*)

**Nutritional and Health benefits**
- Most nutritious leguminous vegetable rich in health benefitting phytonutrients, minerals, vitamins and antioxidants
- Relatively low in calorie and free from cholesterol and adequate amounts of antioxidants such as carotene, lutein, zeaxanthin
- Good sources of proteins, vitamins, soluble and insoluble fibers
- Relatively higher amounts of ascorbic acid (40 mg/100g), and vitamin K (24.8 µg/100g)
- Rich sources of many vitamin B complex vitamins and minerals such as calcium, iron, copper, zinc and manganese

**Flow diagram for manufacture of osmo-air and osmo-freeze drying of green pea**

- Green pea
  - Blanching in 20% sugar syrup at 100°C for 2-3 min
  - Immediate cooling in chilled water for 20-30 min
  - Surface moisture drying at room temperature
  - Cabinet dryer at 50-55°C for 6-8 hrs/Freeze drying at 0.042-0.062 mbar and -92 to -98°C
  - Cooling and packaging in polypropylene pouches and storage at 20-25°C for 6-8 months

**Usage:** Osmo-air and freeze dried pea after rehydration in boiling water for 7-8 min and 4-5 min, respectively can be used in curry or soup preparation.

**Quality attributes**
- Moisture content (1.0-1.5%)
- Decrease in total sugar content (18.55 – 19.34%)
- Decrease in green colour intensity in terms of a value from 11.74 - 12.5%
**Osmo-freeze drying of Carrot (Daucus carota) flakes**

**Nutritional and Health benefits**
- Presence of large quantities of carotenoids precursor of vitamin A
- Act as antioxidant properties and slow down the aging effect
- Rich sources of calcium, potassium, phosphorus and sodium
- Health benefits such as prevention of anemia, atherosclerosis, asthma, cancer, cholesterol, congestion, ulcer, inflammation and improvement in immune system

**Flow diagram for manufacture of osmo-freeze drying of carrot flakes**

```
Carrot
  ↓
Washing and grating to form flakes
  ↓
Blanching in 20% sugar syrup at 100°C for 2-3 min
  ↓
Immediate cooling in chilled water for 20-30 min
  ↓
Surface moisture drying at room temperature
  ↓
 Freeze drying at 0.042-0.062 mbar and -92°C to -98°C
Cooling and packaging in polypropylene pouches and storage at 20-25°C for 6-7 months
```

**Usage**: Freeze dried carrot shreds after rehydration in boiling water for 1-2 min can be used in soup or curry preparation.

**Quality attributes**
- Decrease (10.75%) of initial sugar content of carrot shreds in freeze dried samples during storage
- Decrease in red colour intensity in terms of a value (25.6%) in dried carrot shreds during storage
- Overall sensory acceptability of 8.0 on 9-point Hedonic scale
Freeze drying of Bottle gourd (*Lagenaria siceraria*)

**Nutritional and Health benefits**

- Presence of rich source of vitamins such as vitamin C, thiamine, riboflavin, niacin, vitamin B6, pantothenic acid, folate and vitamin A
- Potential source of higher amounts of minerals such as calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper, manganese and selenium
- Good source of healer for mental health disorders for its highest content of choline than any vegetable known to man till date
- Significant effect to cure patients with shade dried bottle gourd capsules from patients suffering from mental disorders like depression, stress, manic disorders of Gujarat earth quake victims

**Flow diagram for freeze drying of Bottle gourd**

Usage: Freeze dried bottle bottle gourd pieces can be used in milk based sweets.

**Quality attributes**

- Good rehydration ratio of 3.0-3.5 after rehydration in boiling water for 4-5 min
- Good overall acceptability score of 8.0 on 9-point Hedonic scale
Freeze drying of Curry (Murraya koenigii speng.) leaves

Nutritional and Health benefits
- Natural flavouring agent with important health benefits
- More healthy and tasty foods along with pleasing aroma
- Excellent antioxidant properties with control of diarrhea, indigestion, excessive acid secretion, peptic ulcers, cholesterol, antimicrobial, antifungal, antiinflammatory, anticarcinogenic and hepato protective properties
- Good sources of minerals such as calcium, phosphorus, iron, magnesium and copper
- Potential sources of vitamins such as vitamin C, vitamin A, vitamin B complex, vitamin E, plant sterols, glycosides and good for hair growth

Flow diagram for freeze drying of curry leaves

Usage: Dried curry leaves are fried with seasoning to give desired aroma in food.

Quality attributes
- Good rehydration quality with rehydration ratio of 2.5-3.0 in boiling water for 2-3 min
- Good sensory qualities with overall acceptability score of 8.0 on 9-point Hedonic scale during storage
- Decrease in green colour in terms of a value from -7.67 to -5.87 after 5 months of ambient storage of 20-25°C
Freeze drying of Onion (*Allium cepa*) flakes

**Nutritional and Health benefits**

- Excellent sources of vitamin C, sulphur containing compounds such as disulphides, trisulphides, cepaene, flavonoids and phytochemicals
- Rich sources of folic acid, vitamin B complex and dietary fibre
- Improving heart health, reducing inflammation, decreasing the risk of cancer and antimicrobial properties
- Distinct sweetness and aroma due to high levels of antioxidants

**Flow diagram of freeze drying of onion flakes**

Usage: Freeze dried onion flakes can be used as seasoning for increasing flavour in food.

**Quality attributes**

- Overall sensory acceptability score of 8.5 on 9-point Hedonic scale during storage
- Rehydration ratio of 1.5-2.0 in boiling water for 1-2 min
**Freeze drying of Garlic (*Allium sativum*) pieces**

**Nutritional and Health benefits**

- Effective treatment of bronchitis, hypertension, tuberculosis, liver disorders, dysentry, flatulence, colic, removal of intestinal worms, rheumatism, diabetes and fevers
- Assist in prevention of cancers of different body parts such as lung, prostate, breast, stomach, rectal cancer and colon
- Control of atherosclerosis, coronary heart diseases, cholesterol and osteoarthritis in hip joint
- Effective control of Campylobacter bacterium due to presence of diallyl sulfide

**Flow diagram of freeze drying of garlic pieces**

```
  Garlic flakes  ↓
      ↓
    Peeling  ↓
      ↓
    Washing  ↓
      ↓
  Cutting into thin pieces of 0.2 – 0.3 cm  ↓
      ↓
Freeze drying at 0.042-0.062 mbar and -92°C to -98°C  ↓
      ↓
Cooling and packaging in polypropylene pouches and storage at 10-15°C for 5-6 months
```

**Usage:** Freeze dried garlic pieces can be used as seasoning for increasing flavour in food.

**Quality attributes**

- Overall sensory acceptability score of 8.5 on 9-point Hedonic scale during storage
- Rehydration ratio of 2.5-3.0 in boiling water for 4-5 min
Value Addition of Vegetable Crops

Convenience Processed Vegetables

The demand of processed vegetables in India is increasing due to change in food habits and growing income of middle class families. There is a need to process the vegetables by applying low cost technologies as well as innovative processing technologies depending upon the market need so that nutritional security as well as food security could be managed.

Large quantities of vegetables can be preserved by simple low cost steeping preservation with hurdle concept as well drying technologies with the concept of osmotic diffusion process followed by drying to improve the rehydration and sensory qualities of vegetables.

Osmo-air drying is a simple process and has potential advantages for preservation of vegetables for longer duration. The inclusion of osmotic process in conventional dehydration has major objectives of quality improvement and energy savings. This process also results in quality improvement in terms of colour, flavour, texture, product stability, nutrient retention and prevention of microbial spoilage during storage. Different factors such as pre-treatment, nature and concentration of osmotic solution, raw material characteristics, stage of maturity, size of slices, duration of osmosis, ratio of slice to brine concentration and agitation influence the product quality. At the terminal stage, the drying can be achieved by using cabinet dryers or solar driers. Osmo air-drying has greater potential for drying of large quantities of vegetables with good sensory properties. This drying can be adopted as a rural based simple technology by small entrepreneurs, home-scale industry and also by self-help group in close association with NGOs. Small entrepreneurs can adopt this process on large scale. There is ample scope for cost reduction through the use of solar energy for brine concentration and dehydration process.

The demand for convenience type of foods is increasing because of more convenience in terms of labour, time, energy and suitable for particular section of society. Convenience foods have attracted the working women to greater extent as there has been little time for working women to cook food with good taste and balanced nutrition. Different convenience types of foods have been developed to cater the needs of children, adult and aged population.

Many snack foods have attracted the consumers due to crispness and good spicy taste. Very little vegetable based snack and convenience foods are available in the market. Potato chips as snack food are very popular among children and adults. But diabetic patients avoid relishing potato chips due to sugar content. In view of above facts there has been great scope to popularize the vegetable based products as convenience foods.
**Bitter gourd chips (Momordica charantia L.)**

**Nutritional and Health benefits**
- Rich sources of vitamin A, B1, B2 and C and also presence of minerals such as calcium, phosphorus, copper and potassium
- Potential health benefits such as antidotal, antilypolytic, hypogenic, antipyretic tonic, appetizing, stomachic, antibilious, purgative, antiinflammatory, antiﬂatulent and higher healing capacity
- Typical bitter taste with many medicinal values

**Flow diagram for manufacture of bitter gourd chips**

**Usage:** Dried bitter gourd slices are fried in refined oil and are consumed as snack food.

**Quality attributes**
- Moisture (1.0%)
- Good overall acceptability sensory score of 8.0 on 9-point Hedonic scale during storage
- Vitamin C (20-22 mg/100g)
- Rehydration ratio (5.0-6.0)
- Dehydration ratio (5.8-6.0)
- Extent of browning (0.12-0.16)
- Recovery of dried bitter gourd slices (5.5-6.8%)
Ivy gourd chips (*Coccinia grandis*)

**Nutritional and Health benefits**

- Rich source of β-carotene, a major vitamin A precursor from plant sources
- Good sources of protein and fiber and many important minerals such as calcium, phosphorus, iron, copper, and potassium
- Control of diabetic and mechanism reflected due to suppression the activity of certain enzymes involved in glucose production, such as Glucose 6-phosphatase

**Flow diagram of ivy gourd chips**

```
Ivy gourd
  ↓
Washing and cutting into 0.2-0.25 cm slices
  ↓
Blanching treatment at 100°C for 30 sec in 0.1% magnesium oxide followed by dipping in 1% sodium sulphite solution for 10 min
  ↓
Osmotic diffusion treatment in 1% sodium chloride solution at 50-55°C for 1 hr
  ↓
Drying in cabinet dryer
  ↓
I stage of drying at 60°C for 2-3 hrs
  ↓
II stage of drying at 50-55°C for 6-8 hrs
  ↓
Cooling at room temperature
  ↓
Packaging in polypropylene pouches and storage at room temperature at 20-25°C for 6 months
```

**Usage:** Dried ivy gourd slices are fried in refined oil and are consumed as snack food.

**Quality attributes**

- Moisture (1.0-1.50%)
- Ascorbic acid (5.0-6.0 mg/100g)
- Rehydration ratio (2.5-3.0)
- Recovery of dried ivy gourd slices (2.4-2.6%)
**Pointed gourd chips (Trichosanthes dioica)**

**Nutritional and Health benefits**

- Rich sources of carbohydrates, vitamin A, vitamin C, vitamin B1, vitamin B6, etc.
- Good sources of minerals such as calcium, phosphorus, potassium, magnesium, sulphur and chlorine, etc.
- Good for skin and hair growth
- Acts as blood purifier and skin texture clarifier
- Helpful in reducing gastrointestinal diseases, role in salivary tubule active and aids in anorexia

**Flow diagram of pointed gourd chips**

```
Pointed gourd
↓
Washing and cutting into 0.2-0.25 cm slices
↓
Blanching treatment at 100°C for 30 sec in 0.1% magnesium oxide followed by dipping in 1% sodium sulphite solution for 10 min
↓
Osmotic diffusion treatment in 1% sodium chloride solution at 55-60°C for 90-120 min
↓
Drying in cabinet dryer
I stage of drying at 60°C for 2-3 hrs
↓
II stage of drying at 50-55°C for 6-8 hrs
↓
Cooling at room temperature
↓
Packaging in polypropylene pouches and storage at room temperature at 20-25°C for 6 months
```

**Usage:** Dried pointed gourd slices are fried in refined oil and are consumed as snack food.

**Quality attributes**

- Good rehydration ratio of 2.5-3.0 in boiling water for 4 min
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Ascorbic acid (10-12 mg/100g)
- Recovery of dried pointed gourd slices (8.0-8.25%)
Easy-to-cook Fenugreek
*(Trigonella foenum-graecum)* leaves

**Nutritional and Health benefits**
- Good sources of minerals such as potassium, calcium, and iron
- Presence of good dietary fibre enriched with vitamin C and vitamin K
- Fairly good sources of protein and nicotinic acid
- Fosters hair growth, good for the general health and shine of hair

**Flow diagram of easy-to-cook fenugreek leaves**

```
Fenugreek leaves
  ↓
Sorting, grading and removal of field weeds
  ↓
Washing thoroughly in water 3-4 times to remove dirt particles
  ↓
Blanching in 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 80°C for 30 sec
  ↓
Osmotic diffusion treatment of 1-1.5% sodium chloride solution for 30-45 min
  ↓
Drying in cabinet dryer at 55-60°C for 4-5 hrs
  ↓
Cooling and packaging in polypropylene pouches and storage for 6-7 months at 20-25°C
```

**Usage:** Dried fenugreek leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Rehydration ratio (3.0-3.5)
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Vitamin C (35-40 mg/100g)
- Recovery of dried fenugreek leaves (6.8-7.5%)
**Easy-to-cook Bathua leaves (Chenopodium album)**

**Nutritional and Health benefits**
- Store house of nutrients such as 0.8% fat, 4.3% protein, 2.1% dietary fibre and 90 mg/100 g vitamin C
- Good for functioning of liver, spleen and gall bladder
- Good appetizer and improvement in hemoglobin level

**Flow diagram of easy-to-cook bathua leaves**

```
Bathua leaves
↓
Sorting, grading, cleaning and washing in running water 3-4 times
↓
Blanching in 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 80°C for 30 sec
↓
Osmotic diffusion treatment of 1% sodium chloride solution at 55-60°C for 30-45 min
↓
Drying in cabinet dryer at 55-60°C for 4-5 hrs
↓
Cooling and packaging in polypropylene pouches and storage for 6-7 months at 20-25°C
```

**Usage:** Dried bathua leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Rehydration ratio (1.5-2.0)
- Vitamin C (20-25 mg/100g)
- Overall acceptability score of 8.0 on 9-point Hedonic scale
- Recovery of dried bathua leaves (6.5-6.75%)
**Easy-to-cook Spinach**  
*(Beta vulgaris var. bengalensis)* leaves

**Nutritional and Health benefits**
- Store house of many phytonutrients that have health promotional and disease prevention properties
- Rich sources of several polyphenolic antioxidants such as lutein, zeaxanthin and β-carotene, and vitamins such as vitamin A, vitamin C
- Presence of many vitamin B complex vitamins like vitamin B6, thiamine, riboflavin, folates, niacin and rich sources of minerals like iron, potassium, magnesium, copper and zinc

**Flow diagram of easy-to-cook spinach leaves**

Spinach leaves  ↓  
Sorting, grading, cleaning of field weed and thoroughly washing 3-4 times in water  ↓  
Blanching with 0.1% magnesium oxide, 0.1% sodium bicarbonate and 0.5% potassium metabisulphite solution at 100°C for 30 sec  ↓  
Osmotic diffusion treatment of 1% sodium chloride solution at 55-60°C for 30 min  ↓  
Drying in cabinet dryer at 50-55°C for 5-6 hrs  ↓  
Cooling and packaging in polypropylene pouches and storage for 8-10 months at 20-25°C

**Usage:** Dried spinach leaves are fried in refined oil alongwith spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**
- Rehydration ratio (4.0 - 4.5)
- Sensory overall acceptability score of 8.0 on 9-point hedonic scale
- Vitamin C (10-12 mg/100g)
- Recovery of dried spinach leaves (6.0-6.25%)
Easy-to-cook Amaranth 
(*Amaranthus caudatus* L.) leaves

Nutritional and Health benefits

- Rich sources of vitamins such as vitamin A, vitamin C, vitamin D, vitamin E, vitamin K, vitamin B complex and folate
- Fairly good sources of minerals such as calcium, phosphorus, magnesium, potassium, zinc, copper and selenium
- Prevention of inflammation of body such as control of arthritis, gout and kidney diseases
- Rich in high dietary fibre thus controlling high density lipoprotein cholesterol

Flow diagram of easy-to-cook amaranth leaves

Usage: Dried amaranth leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

Quality attributes

- Rehydration ratio (4.5-5.0)
- Sensory overall acceptability score of 8.0 on 9-point Hedonic scale
- Vitamin C (10.0 – 12.0 mg/100g)
Easy-to-cook Cabbage

*(Brassica oleracea var. capitata)* leaves

**Nutritional and Health benefits**

- Excellent sources of many important minerals such as manganese, calcium and potassium and also fairly good sources of iron, phosphorus, magnesium, sodium, zinc and copper
- Presence of vitamin C, thiamine, riboflavin, niacin, vitamin B6, fibre, folate and omega-3 fatty acids thus improving the functional quality in cabbage

**Flow diagram of easy-to-cook cabbage leaves**

1. Cabbage heads
   \[ \downarrow \]
2. Washing and cutting into 1-1.5 cm in length with sharp edged stainless steel knife
   \[ \downarrow \]
3. Blanching of cabbage shreds in 0.1% magnesium oxide at 100°C for 30 sec followed by dipping into 1% sodium sulphite solution for 10 min
   \[ \downarrow \]
4. Osmotic diffusion treatment of 1% sodium chloride solution at 55-60°C for 1 hr
   \[ \downarrow \]
5. Drying in cabinet dryer at 50-55°C for 5-7 hrs
   \[ \downarrow \]
6. Cooling and packaging in polypropylene pouches for 5-6 months at 20-25°C

**Usage:** Dried cabbage leaves are fried in refined oil along with spices followed by addition of water for rehydration during curry preparation.

**Quality attributes**

- Vitamin C (13.0-15.5 mg/100 g) in dried cabbage leaves
- Overall acceptability score of 7.5 on 9-point Hedonic scale
- Rehydration ratio (4.5-5.0)
- Recovery of dried cabbage leaves (6.8-7.5%)
**Instant Protein rich Vegetable Soup Mix**

**Nutritional and Health benefits**
- Nourishing and appetizing qualities
- Comfort food being delicious and easy to make
- Good source of easily digestible nutrients such as protein, vitamins and minerals

**Usage:** About 30 gm instant protein rich vegetable soup mix is reconstituted in 500 ml water and is boiled for 4-5 min and soup is served in hot condition.

**Quality attributes**
- Moisture (4.3-5.5 %)
- Protein (20-23 %)
- Insolubility index (12.25 ml)
- Loose bulk density (0.39 g/cc) and Packed bulk density (0.51 g/cc)
Instant Protein Rich Moringa Soup Mix

Nutritional and Health benefits

- Presence of significant quantities of vitamins A, B and C, calcium, iron and protein
- Fairly high amounts of essential amino acid with the right balance, as well as high amounts of minerals and vitamins
- Control of diabetes and hypertension in adults

Flow diagram of 1 kg instant protein rich moringa soup mix

Usage: About 30 gm instant protein rich moringa soup mix is reconstituted in 500 ml water and is boiled for 4-5 min and soup is served in hot condition.

Quality attributes

- Moisture (5.1-5.6%)
- Protein (21-23%)
- Insolubility index (23.75-24.5 ml)
- Loose bulk density (0.344 g/cc) and packed bulk density (0.446 g/cc)
Pickling and Fermentation of Vegetables

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizer and add to the palatability of meal. Pickles help in stimulation of gastric juice and thus help in digestion. Several kinds of pickles are sold in the Indian market. Mango pickles rank first followed by cauliflower, onion, turnip and lime pickles. Pickles are either manufactured at cottage or home scale as well as commercially manufactured and exported.

Pickling is the result of fermentation by lactic acid bacteria which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acid medium and in the presence of 8-10% salt solution, whereas the growth of majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle manufacturing process. When vegetables are placed in brine, it penetrates into the tissues of vegetables and soluble material present in vegetable tissues diffuses into brine solution by osmosis. The soluble material basically includes fermentable sugars and minerals. The fermentable sugar is broken down by lactic acid bacteria which convert them into lactic and other acids. The acid brine thus formed acts upon vegetable tissues to produce characteristics taste and aroma of pickle.

In the dry salting method, several alternate layers of vegetables and salt are kept in vessel which is covered with acloth and a wooden board is allowed to stand for about 24 hrs. During this period, sufficient juice comes out from vegetables to form brine. The growth of majority of spoilage organisms is inhibited by brine containing 15% salt. Lactic acid bacteria which are salt tolerant, can thrive well in brine containing 8-10% salt. It is therefore, advisable to place the vegetables in 10% salt solution for vigorous lactic acid fermentation. In dry salting method of fermentation, fermentation process starts and carbon dioxide begins to evolve. The salt content is gradually increased to 15% for steady fermentation process. Under favourable conditions, fermentation is completed in 7 to 10 days.
**Vegetable Kimchi**

Kimchi is a traditional fermented Korean delicacy which is made from Chinese cabbage, radish, cucumber with various spices such as hot pepper, garlic, ginger and onions. It is a national dish of Korea and has been referred as staple food since ages. Kimchi is also taken to space by astronauts on a spaceship.

### Nutritional and Health benefits

- Low calorie, high fibre and nutrient rich fermented vegetable
- Rich sources of vitamin A, vitamin B1, vitamin B2 and vitamin C
- Good sources of essential amino acids and minerals such as iron, calcium and selenium
- Abundant amounts of antioxidants such as capsaicin, chlorophyll, carotenoids, flavonoids and isothiocynates with no fat
- Antiaging, antimutagenic, antigenotoxic, antitumor, antimicrobial, immune stimulation, weight controlling, antiatherogenic activity, etc.

### Flow diagram for the manufacture of 1 kg radish kimchi

```
Radish (1 kg)
↓
Washing and cutting into slices
↓
Addition of table salt (25 gm)
↓
Curing at room temperature for 3 hr with occasional mixing
↓
Addition of crushed garlic (10 gm), mixing of red chilli powder (2.5 gm), addition of honey (10 ml) and vinegar (6 ml)
↓
Storage at room temperature (25-30°C) for 24-36 hrs
↓
Addition of sodium benzoate (750-1000 ppm)
↓
Storage at refrigerated temperature (10-15°C) for 3-4 months
```

**Usage**: Radish kimchi is taken as appetizer before taking food.

**Quality attributes**

- Good consumer overall acceptability score of 7.5 on 9-point Hedonic scale during storage
- Decrease in pH from 6.4 to 4.5 during storage
**Mixed Vegetable pickle**

**Nutritional and Health benefits**
- Supply of probiotic or gut friendly bacteria
- Sources of essential vitamins and minerals
- Help in improving digestion and hepatoprotective properties
- Effective control of ulcers and improvement of hemoglobin level

**Flow diagram for manufacture of 1 kg mixed vegetable pickle**

- Mixed vegetables such as carrot (350 g), turnips (350 g) and cauliflower florets (350 g)
  - Frying of chopped ginger (50 g), garlic (25 g) and onion (25 g) in heated mustard oil (200 ml)
  - Washing
  - Cutting into small pieces
  - Blanching in boiling water for 2-3 min
  - Drying of blanched vegetables in sun till the surface moisture is dried
  - Mixing of vinegar (10-15 ml) and jaggery (20-30 g) together
  - Heating till jaggery is dissolved
  - Mixing of all spices such as chilli powder (20 g), mustard seeds (35 g), cumin seeds (10 g), black pepper (10 g), cardamom (10 g), cinnamon (5 g), cloves (3 g) and salts (50-60 g)
  - Store in cool dry place in air tight glass bottles

**Quality Attributes**
- Good consumer acceptability of 8.0 on 9-point Hedonic scale during storage
- Significant decrease in texture of vegetables after 3-4 months of storage
Mushroom Pickle

Nutritional and Health benefits
- Good source of easily digestible protein
- Ideal food for all aged groups
- Balanced supply of vitamins and minerals

Flow diagram for manufacture of 1 kg mushroom pickle

- Mushroom (1.5 kg)
  - ↓ Washing in 0.05% potassium metabisulphite solution
  - ↓ Slicing (4 parts)
  - ↓ Blanching in 0.05% potassium metabisulphite at 100°C for 3-4 min
  - ↓ Drying of blanched mushroom pieces in sun till the surface moisture is dried
  - ↓ Dried mushroom pieces (1kg)
  - ↓ Addition of salt (90 g)
  - ↓ Storage for overnight
  - ↓ Addition of vinegar (15-20 ml), acetic acid (10 ml) and sodium benzoate (750-1000 ppm)
  - ↓ Addition of spices mixture such as mustard seeds (35 g), turmeric (20 g), red chilli (10 g), roasted and ground cumin (1.5 g), aniseed (1.5 g), caraway (10 g), kalaungee (*Nigella indica*) seeds (10 g) and jaggery (15 g) to mushroom pieces
  - ↓ Filling into glass bottles with sufficient heated and cooled mustard oil (200ml)
  - ↓ Mushroom pickle

Quality Attributes
- Overall sensory acceptability score of 8.5 on 9-point Hedonic scale
- Decrease in the hardness of mushroom pickle from 4.08N to 3.67N after 5 months of ambient storage
**Vegetable based sweets**

Sweets are very popular in our Indian culture. Sweets are of great demand in every functions and festivals. It is liked by all sections of society such as children, adult and old people. It is a symbol to welcome guests by offering sweets in our culture.

Various khoa, channa and cereal based sweets are commercially available in every sweetmeat shops. Many heart and diabetic patients often avoid to consume sweets from khoa and channa based sweets.

The demand of vegetable based sweets is increasing because of many nutritional and functional attributes from vegetables in sweets. Among vegetable based sweets, petha is very popular dish of western parts of Uttar Pradesh such as Mathura, Agra and Kanpur. Many petha based industries at small cottage scale as well as big established petha manufacturing industries are located to produce variety of sweets from ash gourd. The delicacy of sweet can be judged that it can be prepared and served in many forms depending upon the choice of consumers. The variation in the variety of sweets from petha is reflected towards crystallized or glazed petha or dipping of cooked ash gourd in concentrated sugar syrup along with flavouring and colouring material for increasing the aesthetic quality. On composition basis, petha based sweets contain on an average 0.4% of fat, 65% of total carbohydrate, 3% of dietary fibre, 0.6% protein and 40% sugar content. Food Safety and Standards Act, 2006 limits the maximum permissible limit of 150 ppm of sulphur dioxide or 500 ppm sorbic acid in finished crystallized or glazed petha.
Nutritional and health benefits of Ash gourd (Benincasa hispida (Thunb. Cogn.))

- Rich sources of crude protein, crude fat, crude fibre, ash and low calorie carbohydrates
- Good sources of essential and nonessential amino acids such as arginine, histidine, lysine, tryptophan, phenylalanine, cysteine, methionine, tyrosine, threonine, leucine, aspartic acid, glutamic acid, proline, serine etc.
- Supply of fatty acids such as palmitic, stearic, arachidic, oleic, linoleic, linolenic etc.
- Medicinal properties such as styptic, laxative, diuretic, effective cure of internal hemorrhages and diseases of respiratory tract
- Popular antimicrobial and antidote of alcoholic poisoning, cure of epilepsy, constipation, piles, dyspepsia, syphilis, diabetes etc
Flow diagram for manufacture of 10 kg crystallized petha

<table>
<thead>
<tr>
<th>Ash gourd (20-25 kg)</th>
<th>Soaking lime (1.0-1.2 kg) in 15-20 litre of water for 2-3 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing in tap water</td>
<td>Separation of lime water from stone</td>
</tr>
<tr>
<td>Cutting horizontally with sharp stainless steel knife</td>
<td>Lime water</td>
</tr>
<tr>
<td>Removal of peel</td>
<td>Dipping of ash gourd pieces in lime water with occasional stirring for 90-100 min</td>
</tr>
<tr>
<td>Immediate pricking with stainless fork</td>
<td>Washing with running water for 5-10 min</td>
</tr>
<tr>
<td>Dipping of ash gourd pieces in lime water with occasional stirring for 90-100 min</td>
<td>Dipping in chilled water (5-7°C) for 1 hr</td>
</tr>
<tr>
<td>Heating of sugar syrup (100°C for 1 min)</td>
<td>Cooking of ash gourd in boiling water (100°C for 5 min)</td>
</tr>
<tr>
<td>Filtration of sugar syrup with 2 folds muslin cloth</td>
<td>Hot water (60-70°C) dipping for 2 min for removal of vegetable flavour</td>
</tr>
<tr>
<td>Sugar syrup (7 kg sugar in 10 kg water)</td>
<td>Cooking of ash gourd in sugar syrup and addition of 10-15 gm sodium bisulphite after the concentration of 50° Brix</td>
</tr>
<tr>
<td>Heating of sugar syrup (100°C for 1 min)</td>
<td>Cooking of ash gourd in sugar syrup and 10-15 gm sodium bisulphite after the concentration of 68-70° Brix</td>
</tr>
<tr>
<td>Filtration of sugar syrup with 2 folds muslin cloth</td>
<td>Removal of sugar coated ash gourd and dry in air overnight</td>
</tr>
<tr>
<td>Soaking lime (1.0-1.2 kg) in 15-20 litre of water for 2-3 hr</td>
<td>Packaging of crystalized petha in polypropylene pouches</td>
</tr>
<tr>
<td>Separation of lime water from stone</td>
<td>Storage at ambient temperature (15-20°C)</td>
</tr>
</tbody>
</table>

Quality attributes

- Good overall sensory acceptability of 8.0 on 9-point Hedonic scale
- Maximum acceptability of crystalized petha with 7.5% lime concentration, 100 min lime water treatment and 70% sugar concentration
- Minimum overall acceptability score of 6.0 on 9-point Hedonic scale with 5% lime water concentration, 30 min of lime water treatment time and 50% sugar concentration
Flow diagram for manufacture of 10 kg *Angoori* petha

- Soaking lime (1.0-1.2 kg) in 15-20 litre water for 2-3 hr
  - Separation of lime water from stone
    - Lime water
  - Sugar syrup (7 kg in 10 kg water)
    - Heating of sugar syrup (100°C for 1 min) and addition of 10-15 gm citric acid for inversion of cane sugar
      - Filtration of sugar with 2 fold muslin cloth

- Ash gourd (20-25 kg)
  - Washing in tap water
  - Cutting horizontally with sharp edged SS knife
    - Cutting with designed mould for shape
      - Removal of peel
        - Pricking with stainless steel fork
          - Dipping of ash gourd pieces in lime water with occasional stirring for 90-100 min
            - Washing with running water for 5-10 min
              - Dipping in chilled water (5°C) for 1 hr
                - Cooking of ash gourd in boiling water (100°C for 5 min)
                  - Hot water dipping (60-70°C) for 2 min for removal of vegetable flavour
                    - Cooking of ash gourd in sugar syrup upto concentration of 60-65°Brix
                      - Cooling to room temperature and packaging in polypropylene pouches with sufficient sugar syrup
                        - Storage at refrigerated temperature (5-7°C) for 7-10 days

Quality attributes

- Good overall acceptability score of 7.5-8.0 on 9-point Hedonic scale during storage for 7-10 days
- Changes in reducing sugar (1.05-1.34%), total invert sugar (31.6-33.4%) and sucrose (30.6-32.9%)
- Extent of browning (0.05-0.06 OD) at 440 nm
Flow diagram for the manufacture of 10 kg Bari from Ash gourd

Usage: Friend spicy bari is relished in vegetarian dishes to satisfy the palate.

Quality attributes
- Good rehydration ratio 3.5-4.0 in boiling water for 5 min
- Good overall sensory score of 7.5 on 9-point Hedonic scale
**Value Addition of Vegetable Crops**

**Manufacture of Pointed gourd (Trichosanthes dioica) sweet**

**Nutritional and Health benefits**
- Presence of significant quantities of vitamins A, B and C, calcium, iron and protein
- Fairly high amounts of essential amino acid with the right balance, as well as high amounts of minerals and vitamins
- Control of hypertension in adults

**Quality attributes**
- Good consumer preference of overall acceptability score of 8.0 on 9-point Hedonic scale
- Shelf life of 15-20 days during storage at 10-15°C
Manufacture of Instant Bottle gourd *kheer* mix

**Nutritional and Health benefits**

- Excellent source of nutrition with minimum calories and fat
- Controlling urinary disorders with flushing excess water from body through urine
- Prevention of premature greying of hair and reduced ageing effect
- Helping in internal cleansing of skin and removing the problems of pimple
- Beneficial effect for early curing of jaundice and inflammation of kidneys

**Flow diagram for manufacture of instant bottle gourd *kheer* mix**

Freeze dried bottle gourd pieces (3-4%)
↓
Addition of powdered sugar (5-5.5%)
↓
Addition of whole milk powder (35-40%)
↓
Reconstitution with 150-175 ml water
↓
Mixing and boiling reconstituted bottle gourd *kheer* for 2-3 min
↓
*Bottle gourd kheer*

**Quality attributes**

- Good overall acceptability score of 8.5 on 9 point Hedonic scale
- Protein content of instant bottle gourd kheer mix (22.0-22.5%)
- Loose bulk density (20.0-20.2 g/cc)
- Insolubility index (22.0-22.5 ml)
** Manufacture of Pumpkin *halwa*

**Nutritional and Health benefits**
- Excellent sources of many vitamins such as vitamin A, vitamin C, vitamin E, vitamin B complex, folic acid, niacin, pantothenic acid, etc.
- Rich sources of minerals such as calcium, magnesium, phosphorus, iron, zinc, selenium, etc.
- Fairly higher amounts of antioxidants such as polyphenolic flavonoid compounds such as β-carotene, cryptoxanthin, lutein, zeaxantin, etc.
- Low calorie vegetables with rich source of cholesterol lowering dietary fibre

**Flow diagram for the manufacture of pumpkin *halwa***

```
Pumpkin (12.5 kg) → Washing and peeling → Peeled pumpkin (10 kg) → Cutting into 2.5-3.0 cm cubes → Addition of melted 150-200 gm ghee in large pan → Cooking of pumpkin cubes in large pan with 1L water with continuous stirring → Removal of watery portion through stainless steel sieve → Addition of sugar (1.5 kg) → Cooking with continuous stirring until concentrated mass reduces the stickiness in pan with glossy appearance → Putting into serving dish and garnishing with 150 gm raisins, 100 gm grated-roasted coconut and 100gm flaked roasted almond → Pumpkin *halwa*
```

**Quality Attributes**
- Good consumer overall sensory acceptability score of 8.0 on 9-point Hedonic scale
- Shelf life of 7-8 days during storage at 10-15°C
हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agricure search with a Human touch