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3 DAYS AgEnt/CISIR AGRO-PROCESSING (FRUITS & VEGETABLES) AND BUSINESS PLANNING/MARKETING WORKSHOP FOR MEDIUM/SMALL AND MICRO SIZE ENTERPRISES AND ENTREPRENEURS

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HARVESTING, HANDLING AND TRANSPORTATION FOR PROCESSING

J.D.MADANAYAKE

The various authorities have estimated that 40 to 60 % of fresh fruit & vegetables produced are lost after harvest. In tropical regions, which include a large proportion the developing countries, these losses can assume considerable economic and social importance. As the value of fresh product may increase many time from farm to the retailer or manufacturer, the economic consequences of wastage at any point along the chain Are serious.

Fruit and vegetable are frequently grown at locations remote from the major centres of population. Thousands of tunnels of produce ore now transported daily over long distances both within country and internationally. Fresh fruit and vegetables are important items of commerce, and there is a huge investment of resource in transport, storage and marketing facilities designed to maintain a continious supply of these perishable commodities.

The main import factors involved in post harvest losses are.

1. Irregular harvesting practices
2. Irregular handling
3. Irregular storage
4. Irregular transportation and distribution

The main role of the post harvest technologist is to devise methods by which deterioration of produce is restricted as much as possible during the period between harvest and consumption.

General Principles & Methods of Preservation of Fruits & Vegetables

Malini Mallawaratchie

Fruits & Vegetables are highly perishable. They can be kept in a good condition only for a short time after harvest.

1. Composition of Fruits & Vegetables

Table I gives the composition of some common fruits & vegetables. It can be seen that fruits & vegetables have the following properties and all our methods of preservation should aim at preserving the desirable properties.

(i) High Vitamin C

(ii) High Vitamin A

(iii) High Minerals

(iv) Fair source of utilisable carbohydrates - starch $\rightarrow$ sugar

(v) High in organic acids

(vi) Good colour - chlorophyll, carotenoids, anthocyanins

(vii) Good flavour

(viii) Desirable texture - intermolecular bonding by pectic substances, Cell wall metabolism results in texture changes & softening

The high moisture levels (70 - 95%) of fruits & vegetables result in a high degree of perishability.

2. How & Why Fruits & Vegetables get spoilt

The quality of fruits & vegetables cannot be improved after harvest. If they are harvested before physiological maturity they often have not developed mechanismsto enable these changes to occur normally. The metabolic events are affected by the environment and the maturity at harvest.

Factors causing spoilage of fruits & vegetables

1. Damage and Injury to Skin

This could be caused by poor handling and transport. Microorganism generally are not found within healthy living tissue of plants but are always present to invade the flesh through a break in the skin or if the skin is weakened by disease or death. The major pathogenic microorganisms of fruits are fungi while those of vegetables are bacterial soft rots. These can penetrate through a wound or through the skin or cuticle of the host tissue. eg. anthracnose - penetrates skin before harvest and rots develop after harvest. Hence good orchard hygiene and careful storage are required. Compounds released from the injured cells could also cause tissue browning (enzymatic browning) which affects the colour and flavour. There is also increased respiration and ethylene production is stimulated resulting in faster ripening.

2. High Moisture

Bacteria, yeast and mould like moist and warm climates to live. High moisture levels are ideal for microorganisms to thrive, Bacteria multiply fast. They generally double every 30 minutes. When they grow on fruits & vegetables they could cause fermentation and production of toxins. Washing of fruits & vegetables reduces the microbial load.

3. Chemical Changes

Various chemical changes could affect the colour and flavour.

4. High Temperature Storage

Mersophillic microorganisms could grow Vitamins could decrease, off flavours could increase and texture breakdown could occur.

5. Low Temperatur Storage

Chilling injury where skin discolouration, pitting, flesh browning, uneven ripening, rapid development of rots could occur.

6. High humidity/dryness

High humidty storage increases microorganisms, enzymatic action and chemical reactions. Dryness causes willting loss of turgidity and shrivelling.

7. Light

Vitamins A & C could decrease. Food colours like carotenoids are affected.

8. Presence of Oxygen

This affects vitamin A and C. Colour and flavour decrease while mould growth increases.

9. Time

Time affects all the above changes. Microbial loads and enzymes, non enzymatic reactions, flavour loss all increase with time.

Only good quality fruits & vegetables should be used for processing.

3. **Why should you prevent the spoilage of fruits & vegetables ?**

1. Seasonal gluts are made available during off season.
2. Reduction of seasonal glut
3. Retention of nutritive value
4. High fibre levels are good for digestion
5. Product quality improved in terms of colour & flavour
6. Protect from damage/injury

Many fruits and vegetables are capable of being processed into palatable foods after destroying the micro-organisms on them.

4. Principles of Methods of Preservation of Fruits & Vegetables

The most desirable principle of preservation is to prevent contamination by microorganisms and chemicals by good manufacturing practices. This applies to the raw material prior to arriving at the factory (correct applications of pesticides, proper harvesting, handling, transportation, storage) and during processing itself.

Short term Storage Methods

1. Waxing
2. Low temperature storage -(humidity should be controlled to prevent moisture loss from product)
3. Controlled Atmosphere Storage

Long term Storage Methods

1. Destruction of microorganisms/enzymes by

   Heat - Pasteurization (ready to serve drinks)
   - Sterilization (canning, fruit juice)

   (to kill microorganisms but minimize alteration to food)

   Preservation - Chemical Preservation (squash/cordial, ready to serve drinks)

   (use minimum levels to inhibit microbial growth but minimize adverse effects upon food components and human health)

   Irradiation - Radiation Preservation (inhibit potatoe sprouting)

2. Retard growth of microorganisms/enzymes and chemical reactions by low temperature - Refrigeration

3. Retard growth of microorganisms by increasing acidity
   - Pickling (vinegar pickles)
   - Fermentation (gherkins)

4. Reduce moisture available in product for the growth of microorganisms by
   - Dehydration (Dehydrated fruits & vegetables)
   - Freezing (Frozen fruits & vegetables, fruit juices, TQF)
   - High sugar preservation (Jam, Preserves)
   - Salting (Lime pickle)

5. Remove oxygen and prevent growth of microorganisms and chemical reactions.
   - Vacuum Packaging
   - Modified atmosphere packaging

In addition to the above methods of preservation, certain pretreatments are also used in the preservation of fruits & vegetables.

Blanching - Mild heat to inactivate enzymes (generally done for vegetables)

Sulphite dip/ascorbic acid dip - to inactivate enzymes (generally for fruits)

Sulphite treatment - prevent non-enzymatic browning (fruit/vegetable dehydration)

Table I - Values per 100 g edible portion

Fruits/Vegetables	Moisture (g)	Energy (Kcals)	Protein (g)	Fats (g)	Carbohy-drate (g)	Vitmin C (mg)
Fruits						
Banana, ripe	70.1	116	1.2	0.3	27.2	7
Guava	81.7	51	0.9	0.3	11.2	212
Lime	84.6	59	1.5	1.0	10.9	63
Mango,ripe	81.0	74	0.6	0.4	16.9	16
Nelli	81.8	58	0.5	0.1	13.7	600
Avocardo	73.6	215	1.7	22.8	0.8	-
Papaya	90.8	32	0.6	0.1	7.2	57
Passion fruit	76.3	54	0.9	0.1	12.4	25
Pineapple	87.8	46	0.4	0.1	10.8	39
Vegetables						
Beetroot	87.7	43	1.7	0.1	8.8	10
Carrot	86.0	48	0.9	0.2	10.6	3
Cabbage	91.9	27	1.8	0.1	4.6	124
Gotukola	84.5	27	2.1	0.5	6.0	-
Kankun	90.3	28	2.9	0.4	3.1	137
Mukunuvenna	77.4	73	5.0	0.7	11.6	17
Brinjal	92.7	24	1.4	0.3	4.0	12
Beans	91.4	26	1.7	0.1	4.5	24
Tomato	94.0	20	0.9	0.2	3.6	27

Tables of Food Composition for use in Sri Lanka
(World Health Foundation of Ceylon)

TOMATO SAUCE

Product	-	A product prepared from sieved, cooked fruit/vegetable pulp.
Raw Materials	-	Tomatoes, salt, vinegar, spices, sugar preservatives.
Equipment	-	Pulper & Siever, ROPP bottle sealer, S.S. vessels, Brixmeter, gas cooker, pestal & motar, bottles and lids.

SAUCE MANUFACTURE

FLOW CHART

Tomatoes

|

Sorting

|

Washing

|

Pulping

|

Filtering

|

Concentrate by heating

|

Addition of spices

|

Concentrate till Brix 42°

|

Addition of preservatives

|

Bottling

|

Sealing

|

Bottled sauce

FRUIT JAM

Product	:	A semi-solid product prepared from fruit pulp.
Raw Materials	:	Fruit- Mango/Pineapple/Papaya/ Woodapple/Tomato, sugar, citric acid, pectin.
Equipment	:	Pulper , Siever, Cooker, Bottles/Lids, pH meter, Brix Meter, Sealer.

Production of Jam - Flow Chart

Fruits

|

Washing

|

Peeling

|

Cutting

|

Removal of Seeds

|

pulping

|

Heating with citric acid

|

Addition of pectin & sugar

|

Heating

|

Add remaining sugar

|

Heat till Brix 68.5 & pH 3.5

|

Bottling

|

Bottled Jam

FRUIT/VEGETABLE CANDY

Product	:	The product has a pleasant flavour and a chewy texture can be used in desserts and confectionery.
Raw Material	:	Fruits - Pineapple/Papaya Vegetables - Silvermelon, Pumpkin, Carrot, Dubai Pumpkin Sugar, Preservatives, Citric Acid.
Equipment	:	Stainless Steel vessels, Hot air dryer stainless steel trays, Brix Meter, pH meter. Air tight vessels.

FRUIT/VEGETABLE CANDY

FLOW CHART

Fruits/Vegetables

|

Sorting

|

Washing

Sugar syrup

|

Peeling/deseeding

Filtering

|

Slicing

Heating

|

Blanching

|

Soaking in sugar syrup

|

Gradual increase of sugar concentration

|

Draining from syrup

|

Drying

|

Packing

|

Fruit/Vegetable Candy

Preparation of Fruit Beverages

D. Medis

Fruit beverage , which is a very popular cool drink in the present market, is a method of juice preservation. As it contains vitamins, minerals, carbohydrates which are very important for the growth and metabolic actions of the human body, it is necessary to take care about these nutrients during processing. In the fruit beverage industry, the destruction of nutrients, wastage and the spoilage of drinks can be minimised by applying proper scientific technology.

The fruits mainly used for drinks in Sri Lanka are mango, passion fruit, pineapple, papaya, wood apple and lime.

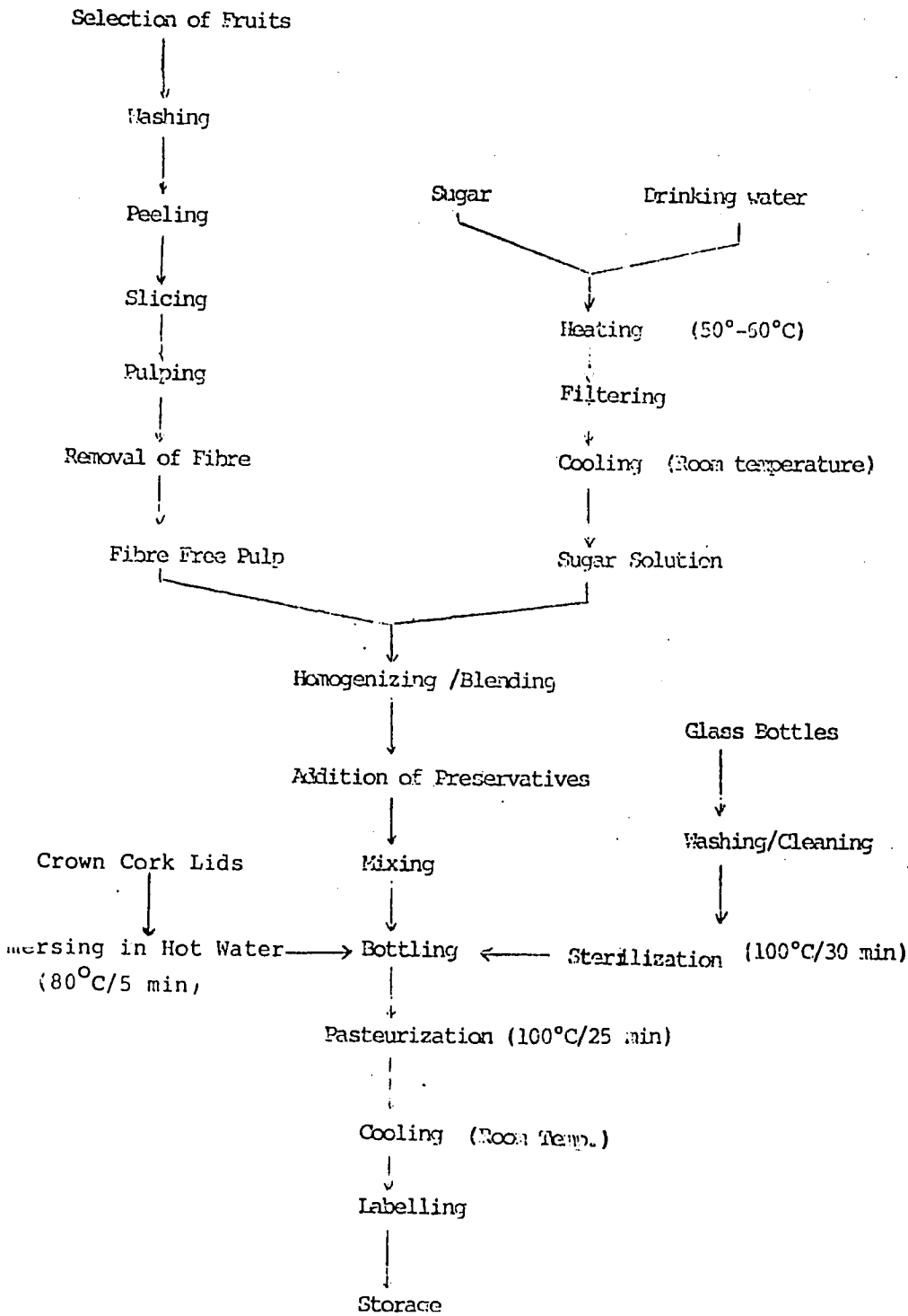
Fruit Cordial/Squashes

Fruit cordial is a kind of syrup prepared by mixing fruit juice and sugar. When consuming, it is necessary to dilute the syrup by adding adequate water.

Ready-To-Serve Fruit Beverages

The RTS drinks are diluted cordials, prepared by mixing fruit juice, sugar & water and can be consumed as it is. The bottle once opened, cannot be preserved.

FLOW DIAGRAM FOR READY-TO-SERVE BEVERAGES



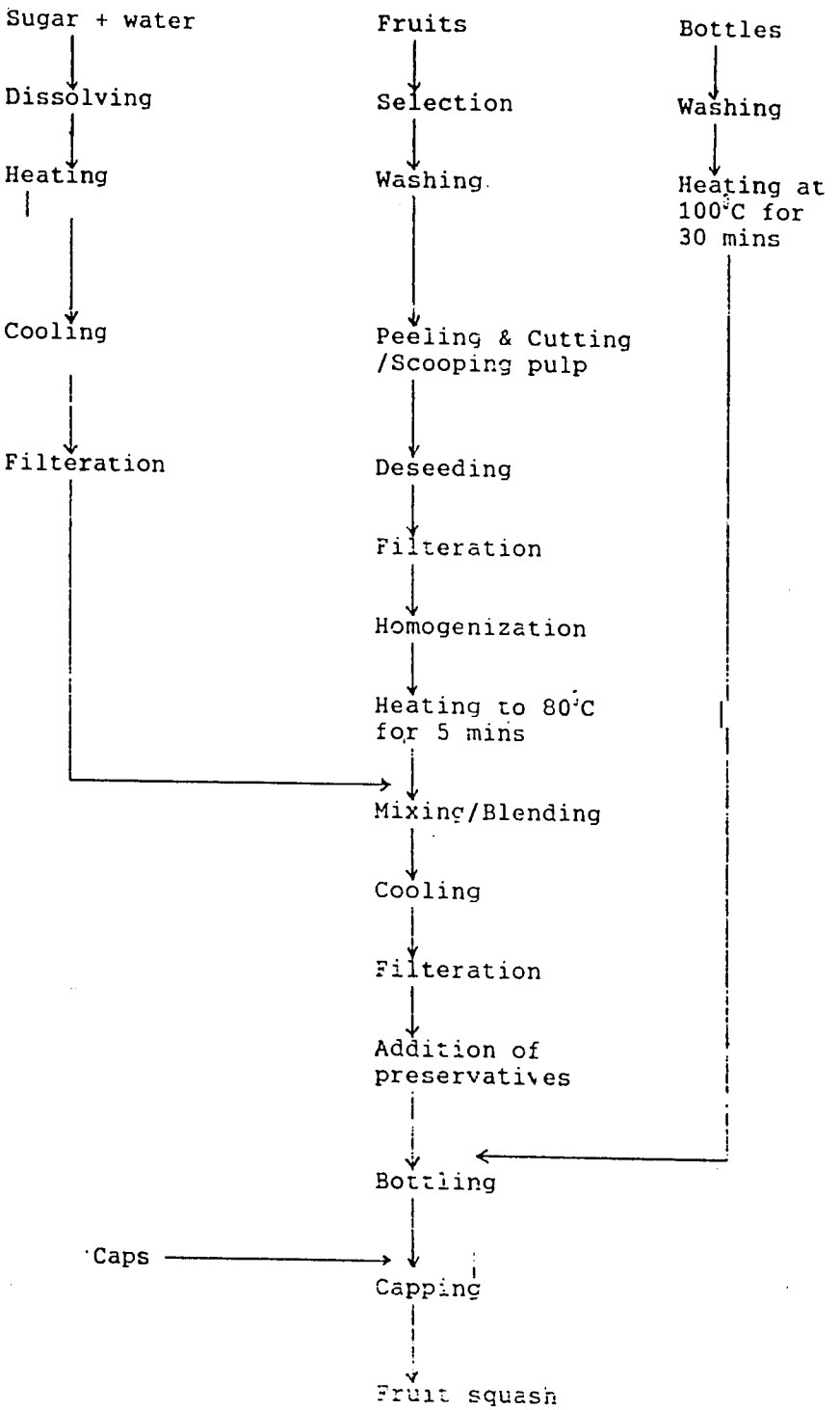


Figure I -Flow Diagram for the Manufacture of Fruit Squash

ENHANCING PRODUCT PACKAGING

Malini Mallawaratchi

1. PRINCIPLES OF FOOD PACKAGING

1.1 Functions of a Food Package

* Non toxic and compatible with specific food
* Sanitary protection
* Moisture and fat protection
* Gas and odour protection
* Light protection
* Resistance to impact
* Transparency
* Tamperproofness
* Ease of opening
* Pouring features
* Reseal features
* Ease of disposal
* Size, Shape, weight limitations
* Appearance, printability
* Low cost
* Special features

1.2 Food Packaging System

Food packaging is a system of closely related components.

1. Food product
2. Package
3. Environmental factors.
4. Processing
5. Packaging machinery
6. Distribution systems
7. Waste disposal
8. Economics
9. Marketing
10. Regulations.

2. PRESENT METHODS OF PACKAGING PROCESSED FRUITS & VEGETABLES

Primary Packaging

Fruits in syrup, vegetables in brine, fruit juice, fruit jam etc.	Open top sanitary cans lacquers, hermatic seal.
Chutnies, sauces, fruit jams, pickles, squash, ready to serve drinks.	Glass bottles with Omnia lids, ROPP seals, crown corks., lug caps
Dehydrated fruits & vegetables -	Cellophane, Oriented poly-propylene.
Secondary Packaging -	- Cardboard cartons

3. PACKAGING MATERIALS AND THEIR PROPERTIES

3.1 Glass

Advantages - Strong, total protection, transparent, recyclable.

Disadvantages - Heavy, fragile.

3.2 Metals

3.2.1 Tin cans - Tin layer on steel base plate, lacquered.

Advantages - Excellent physical properties.

Disadvantages - Heavy, opening & reclosing, detinning.

Now - Tin free steel, welded cans, beaded cans.

3.2.2 Aluminium Cans - for fruit drinks

Advantages - Light, corrosion resistant, recyclable.

Disadvantages - Costly, poor & structural strength.

3.2.3 Metal Foil - Aluminium

Metallized film - Aluminium layer on film/paper. Protection from moisture, oxygen, light, flavour loss.

3.2.4 Closures - Cans - Hermetic seal.
Bottles - Twist off caps/lug caps.

3.3 Paper

Advantages - Inexpensive, recyclable
Disadvantages- Poor barrier to gas and vapour loss.
Poor strength when wet.

Now - Polythene coated paper) Improved vapour/gas
Laminating or metallized paper) barrier.
)
Polyester coated paper - Withstands high temperature

3.4 Plastics

Choice of plastic depends on several factors eg. strength, barrier properties, heat sealability etc.

3.4.1 Polythene (PE)

Advantages - Cheap, excellent moisture barrier, heat sealable.

Disadvantages- High gas & vapour transmission, LDPE & HDPE

3.4.2 Polypropylene (PP)

Advantages - Good gas barrier, transparent
Good heat resistants.

Disadvantages- Expensive, difficult to heat seal.

Oriented Polypropylene (OPP) - Better properties

3.4.3 Polyvinyl Chloride (PVC)

Advantages - Tough, excellent moisture resistance, low gas permeability.

Disadvantages- Vinyl chloride monomer.

Now - Food grade PVC film - monomer < ppm

3.4.4 Polyester (PE)

Polyethylene terephthalate (PET)

Advantages - Strong, recyclable, excellent barrier properties.

Disadvantages- High cost.

3.5 **Multi Layer Films**

3.5.1 Laminates - Two or more layers of material bonded with adhesive or lower melting plastics. eg. Retort

Retort pouch - Polyester/Al foil/PP

Aseptic pack - LDPE/Paper/LDPE/ Al foil/EAA/LDPE

Unit packs for jam - Thermoformed PP Laminated with foil/HDPE

3.5.2 Coextruded - Several layers of plastic extruded at once with adhesive/tie layers. eg.

3.6 **Multi layer Co-extruded squeezable bottles**

4. NEW PACKAGING TECHNIQUES

4.1 Vacuum Packaging

The product is placed in a film of low oxygen permeability and air is removed under vacuum. Very low O_2 levels and increased CO_2 levels increase the shelf life of the product.
packaged dehydrated fruit.

4.2 Aseptic Packaging

The food product and the packaging material are sterilized separately and packed under sterile condition. Aseptic packaging is used for fruit juices, ready to serve fruit drinks etc.
Eg. Al or paperboard with other plastic materials.

4.3 Shrink Wrapping

Product wrapped with PE/PVC film and passed through hot chamber when the film shrinks and takes the shape of the object.
Uses - temperproofness, collation marketing.

4.4 "Bag in Box" Packaging System

Palstic bag fitted with spout covered by a valve contains the product and is supported within a unit of corrugated paper, plastic, steel, fibre board etc.

Eg. Tropical fruits (purees, crushed pineapple, pineapple juice concentrate).

Met. PET/PE. simple or double layer institutional/bulk pack

Soft drink Soft drinks and juice concentrates - PE/EVA/Nylon

Tomato products (as puree, paste, crushed, diced, ketchup, pizza sauce). (Aseptically processed).

Met. PET/PE

4.5 "Boil in Bag" Packaging

Product should be capable of beeing frozen and then boiled.

Eg. HDPE/PP copolymer.

PET.

4.6 Modified Atmospheric Storage

The normal composition of air is modified within a package by reduction of O_2 content of air in the package headspace while increasing the level of CO_2 and N_2. The products shelf life is extended without using chemical or physical treatments.

5. GREEN PACKAGING

Developing countries may face international trade restrictions for exports with prohibitions on a particular packaging materials or type of packaging because it is not environmentally friendly.

Factors Affecting Choice of Green Packaging

1. Source reduction
2. Energy requirements
3. Pollution caused by packaging manufacture, use or disposal
4. Potential for reuse
5. Potential for recycling
6. Ease of disposal
7. Eco balances
8. Eco labelling.

6. Sri Lanka Standards on Packaging

CS 147 : 1972	Rigid up plasticized PVC pipes for potable cold water supplies.
SLS 266 : 1973	Code of packaging in plastic containers.
SLS 211 : 1973	Mtd. for labelling and marketing of containers for essential oils.
SLS 212 : 1973	Mtd. of packing of essential oils.
SLS 228 : 1973	Glass bottles with crown finish
SLS 290 : 1974	Glass liquor bottles
SLS 291 : 1974	Glass bottles for aereated water
SLS 467 : 1979	Code of practice for labelling of packaged foods.
	Part I : 1979 General guidelines
	Part II : 1979 Guidelines on claims
SLS 503 : 1980	Hermetically sealed metal cans for milk.
SLS 601 :	Glass container finishes
	Part I : 1983 Threaded finishes
	Part II : 1983 Crown finishes
	Part III: 1984 Omnia finishes
	Part IV : 1984 Lug finishes

SLS 628 : 1983	750 ml glass bottles with 31.5 mm std ROPP finish for edible products.		
SLS 714 : 1985	PVC bottles for packing edible products.		
SLS 719 : 1985	Glass jam jars.		
SLS 789 : 1987	325 ml glass bottles 31.5 mm std. ROPP for edible products.		
SLS 871 :	Code for use of plastics for food contact applications.		
	Part I :	1989	General guidelines for manufacturing
	Part II :	1989	PVC
	Part III :		PE
	Part IV :	1991	PP
SLS 972 : 1992	Code of practice for packaging of lobsters and prawns for export.		

EQUIPMENT FOR FRUIT AND VEGETABLE PROCESSING

P.PRIYANANDA

There are some important common factors to be considered in selecting machinery and equipment for processing of any food.

(1) The equipment should be made out of a suitable material. All food contacting parts should be made out of food grade material.

(2) The equipment should have been designed according to strict sanitary standards. No crevices, cracks or corners should present which can act as growth sites for bacteria and other microorganisms.

Equipment for fruit and vegetable processing are available for different technological levels of processing. They can be hand operated, semi mechanized or fully automatic. But the unit operation which is performed by a particular equipment is independent of its mode of operation.

A complete process can be considered as a integrated line of individual unit operations. When the entire line of unit operations are mechanized the production quality and output is good. But capital expenditure is high. When fruit and vegetable processing is done in small scale many of the unit operations (sh.peeling, cutting) can be done manually.

Pulping is one of the essential unit operation in fruit processing, which is essential to mechanized. There are different types of fruit pulpers, the one with rotating brush in a stainless steel cylindrical mesh is the most common.

Another very important step in fruit and vegetable processing is heating. This can be done by placing a saucepan on a gas flame. But the product quality may not be very good due to overheating of the surface of the saucepan.

To perform the same operation in a better way steam jacketed vessels are used. As steam jacketed vessels are introduced, high level of output & technical operation is demanded by the process. The capital investment is also high.

Canning and dehydration of vegetables are very common preservation methods for fruits and vegetables. When the product pH is greater than 4.5 canning should be done at a higher temperature using a retort.

For dehydration of fruits and vegetables the most important equipment is the drier. There are different types of dryers sh. solar dryers, kerosene fired dries, fire wood fired ones etc.

The selection will depend on the economy, the type of material to be dried and the target market.

SEMI PROCESSING OF PULP

Malini Mallawaratchie & S.Jayakody - CISIR

Principle of Preservation

When fruit pulp is manufactured from fresh raw material, the pulp has an initial level of micro-organisms. When the pulp is given a heat treatment this level is reduced. Unless this heat treatment is such that all the microorganisms present in the sample are destroyed and not allowed to grow again by adequate sealing (hemetic seal), like in canning, these microorganisms left tend to grow and with time cause spoilage of the pulp. To prevent this, we add preservatives like sodium metabisulphite. This chemical releases SO_2. SO_2 in solution at low pH levels acts on microorganisms and prevents them growing. Lowering the pH i.e. increasing the acidity of the food, also prevents microorganisms growing in the food. These are the principles of food preservation used in the semi-processing of pulp for storage.

Semi-processing of Tomato Pulp

CISIR has developed technology for the semi-processing of tomato pulp on a project funded by International Development Research Centre, Canada. Conditions have been optimized to obtain a excellent quality tomato pulp with a shelf life of 3 months using reduced SO_2 levels. It does not require refrigerated storage. Tomato sauce prepared from stored pulp rated very well in colour, consistency and flavour when compared with sauce made from fresh tomatoes.

The flow diagram for manufacture of tomato pulp is given in Fig. I.

Semi-processing of Mango Pulp

On the same project, CISIR has developed technology for obtaining excellent qualities mango pulp with a shelf life of 3 months using reduced SO_2 levels. It, too, does not require refrigerated storage. Mango cordial and mango jam prepared from stored pulp rated very well in colour, appearance, taste and odour when compared with that prepared from fresh pulp.

Other methods of pulp preservation

In addition to the above methods the standard method of preservation of fruit pulp is by heating the pulp to inactivate enzymes, acidifying with citric acid and preserving with SO_2 (added as sodium or potassium metabisulphite). High levels of preservative are used, ranging from 1000-2000 ppm of SO_2. The level of SO_2 is monitored and maintained throughout the storage period. Care should be taken to see that the containers are full and there is no loss of SO_2 is during storage. It may be desirable to top up the pulp in the containers occasionally. The pulp is kept until the next season.

Another method of fruit pulp preservation is by freezing the fruit pulp. The pasteurized pulp is cooled and blast frozen prior to storage at -20^{0}C. This method of pulp preservation is expensive but gives a superior quality product.

Fresh, ripe, red tomatoes

↓

Washing

↓

Cutting

↓

Pulping

↓

Straining

↓

Acidification

↓

Heating

↓

Cooling

↓

Adding preservative

↓

Filling into food grade plastic cans

↓

Closing

↓

Storage

↓

Semi processed tomato pulp

Figure 1 Flow diagram for semi processed tomato pulp

Ripe Mangoes
↓
Sorting
↓
Washing
↓
Peeling
↓
Cutting
↓
Pulping
↓
Addition of water
↓
Acidification
↓
Heating
↓
Cooling
↓
dding preservative
↓
ling into food grade
plastic cans
↓
Closing
↓
Storage
↓
processing mango pulp

Fig 2 Flow diagram for semi processed mango pulp