

## 14. Preservation



### Can you recall?

Food is one of the basic necessities for sustenance of life. Fresh, clean, pure, hygienic and healthy food is highly essential for protection and maintenance of health of the people. Therefore, it is the responsibility of Government to provide regulatory systems for food safety and consumer protection.

### 14.1 FOOD LAWS AND REGULATIONS

Earlier, the regulatory frame work involved was of multiple agencies with overlapping functioning which prevented a smooth and co-ordinated execution. Various acts and orders for food safety in India are in vogue viz. Prevention of Food Adulteration Act 1954, Fruit Products Order, 1955, Meat Products Order, 1973, Milk and Milk Products Order, 1992, Edible Oil Packaging (regulation) Order, 1998, Standard of Weights and Measures Act and Rules 1956, Essential Commodities Act 1955, etc. These were governing food products regulations.

Considering the food adulterations, food borne illness, food handling hazards and World Trade Organization mandate it became imperative for the local food business operators to match up to the International Food Standards of food commodities.

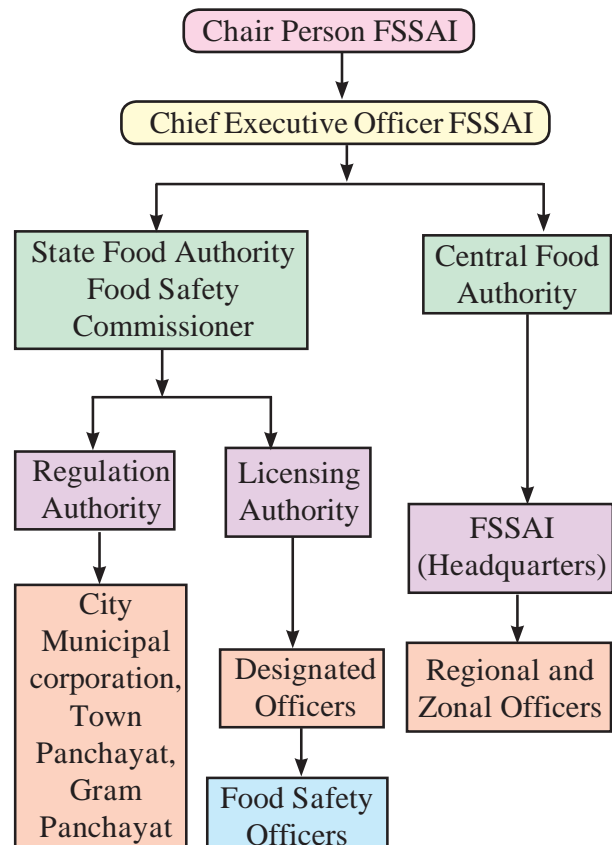
Therefore, the Government of India enacted a comprehensive Act, The Food Safety and Standards Act(FSSA) in August, 2006.

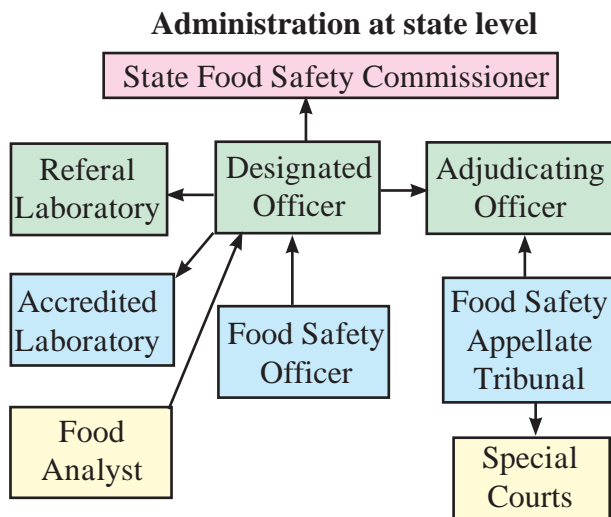
The food may be processed, partially processed, unprocessed, genetically modified or engineered. Primary food, the produce of agriculture, horticulture, animal husbandry, dairying, or aquaculture in its natural form, unless with a farmer or fisherman are also covered under this Act. Main focus of this Act is to ensure safety and quality across the food chain. Therefore, every food business operator

handling food at any stage of manufacturing, processing, packaging, storage, transportation, distribution of food, import, food services, entering services, sale of food or food ingredients fall under the preview of this Act. The FSSAI is an independent statutory Authority with its headquarters in New Delhi, administered by Ministry of Health and Family Welfare, operates through four Regional offices in New Delhi, Kolkata, Mumbai, Chennai and four sub-Regional offices in Lucknow, Chandigarh, Guwahati and Cochin.

**14.1.1 Regulatory Mechanism :** FSSAI (Food Safety and Standards Authority of India) responsible for the enforcement of various provisions of the Act. They monitor and verify whether the relevant requirements are being fulfilled by food business operators. They maintain a system of control including public communication on food safety and risk, food safety surveillance and other monitoring activities covering all stages of food business.

#### Organization structure of FSSAI





**Fig. 14.1 Preserved fruit products**

### 14.2.1 Principles of preservation :

In general fruits and vegetables deteriorate in quality or get spoiled mainly because of biochemical action of enzymes in the fruits and vegetables or of those that are affected by moulds, yeasts and bacteria; or purely chemical action or by physical means like bruising, moisture loss or gain, temperature extremes, absorption of foreign colours and attack of insects and rodents. Preventing all these should be the basis of food preservation.

William C. Frazier (1894-1991), a food microbiologist, outlines the principles underlying the various methods of food preservation as follows:

#### 1. Preservation or delay of microbial decomposition :

- a. By keeping out micro-organisms by sanitary handling (asepsis)
- b. By removal of micro-organisms e.g. by filtration.
- c. By hindering the growth and activity of micro-organisms by low temperature, drying, anaerobic conditions or chemicals.
- d. By killing micro-organisms, e.g., by heat or radiations.

**a. Asepsis :** Avoiding micro-organisms is aimed at preventing initial spoilage. Natural protecting cover around the food is provided by shells of nuts, by skin or peels of fruits and vegetables, the husks of ear corn, the shells of eggs and the skin, membrane or fat on meat or fish. In advanced packaging technology, food material packed in loose cartons or wrapper to a hermetically sealed (aseptically) container for canned foods.

**14.1.2 Food Safety Standards Regulation :** It encourages self-regulation by Food Business operators (FBO). FSSAI has to perform the following regulations (Act and Orders)

1. FSS – Licensing and registration of food Business, Regulations 2011
2. FSS – Food Products Standards and Food Additives, Regulation 2011
3. FSS – Production and Restriction on Sales Regulations 2011
4. FSS – Food Product Standards and Food Additives, Regulations 2011
5. FSS – Contaminants, Toxins, and Residue Regulations 2011
6. FSS – Laboratory and Sampling Analysis Regulations 2011

## 14.2 PRESERVED FRUIT PRODUCTS



### Do you know ?

The present processing level of fruits and vegetables into value added products in our country is about 23%. However it was around 2 - 3% in the year 2002-03. The significant increase is due to the promotional schemes/projects launched by the Ministry of Food Processing Industries, Govt. of India. The level of processing of fruits and vegetables in other countries are at about 80% in Thailand, 78% in philippines, etc.



### Do this

1. Study the different types of fruits and vegetables available in the local market.
2. Group them according to their shape, type, fruits, vegetables, taste, colour, etc.

Sanitary methods of handling food from the source of production to the final point of use coupled with the control of environmental factors to inhibit microbial multiplication of the few contaminants will result in the preservation of the food.

**b. Removal of micro organisms** may not be very effective but helpful in reducing the contaminants. Rinsing raw food with potable water removes most of the soil organisms on the surface of fruits and vegetables. After this treatment, sanitary handling of the food is necessary to prevent re-contamination. The surface of the rinsed food should not be left moist as this encourages growth of whatever organisms may be left behind.

Trimming away the spoiled portions of a food may help in reducing the amount of contaminants that can proliferate and cause spoilage of fruits and vegetables.

**c. Hindering the growth and activity of micro organisms** used to control the activity of microorganisms are in fact methods that alter environmental conditions like temperature, moisture, oxygen and pH of the food to a state unfavourable for microbial spoilage. Refrigeration and freezing slow down or stop microbial growth in chilled and frozen food. Drying reduces the level of moisture in food which is unfavorable for growth of micro organisms. Evacuation or vacuumization food pack will limit the oxygen and thus hinder the growth of micro-organisms.

**d. Killing microorganisms by heat** is the application of pasteurization or mild heating and sterilization with a more intense heating will reduce micro organisms by killing most of them. Coupled with improved packaging in hermetically sealed containers, microbial

spoilage is significantly controlled. Canned and retortable pouch processed food are best examples.

### 2. Prevention or delay at self-decomposition of the food :

- a. By destruction or inactivation of enzymes e.g. blanching
- b. By destruction or delay of purely chemical reactions such as preventing oxidation by means of an antioxidant.

#### a. By destruction or inactivation of enzymes:

The method used to control the activity of microorganisms usually are effective against self-decomposition of the food which is brought about by enzymes. For example, the blanching of fruits and vegetables in boiling water inactivates the enzymes and is particularly an important pretreatment for freezing and dehydration.

#### a. Preservation or delay of purely chemical reactions :

Decomposition of refined oil (rancidity), non-enzymatic browning or amino-aldehyde reaction, oxidation of ascorbic acid (vit. C) are examples of purely chemical reactions. Temperature, moisture and oxygen favour these chemical reactions. The use of antioxidants (BHA) and oil containing antioxidant (vit. E) will prevent the problem.

### 3. Prevention of damage by insects, rodents and mechanical causes :

This requires the use of packaging and sanitary storage measures with moisture and temperature control to protect the food from damage caused by insects and rodents. Careful handling, proper packaging will check the mechanical damage of fruits and vegetables.

#### 14.2.2 Preparation of value added products :

**I. Jam :** Jam is prepared by boiling the fruit pulp with a sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in the mass. In its preparation about 20.4 kg of fruit pulp should be used for every 24.9 kg of sugar. It should contain not less than 68.5 percent soluble solids as determined

by refractometer (expressed as degree brix) when cold. As per the FSSAI (FPO,1955) specifications, jam may be prepared from one kind of fruit or from combination of two or more fruits.

The fruit used shall be mature, ripe, fresh, firm, sound, clean and free from fermentation and mould. Pectin derived from any fruit may be used when necessary. The other substances added are sugar, essence, permitted colours, citric acid and preservatives. No artificial sweeteners shall be added.

A jam is more or less concentrated fruit having a fairly thick consistency and firm body. It is also rich in flavour because of ripe fruit, which has developed full flavour, used in its preparation. Pectin present in the fruit gives it a good setting. High concentration of sugar facilitates preservation due to its osmotic pressure.



Fig. 14.2a Fruit Jam



Fig. 14.2b Fruit Jam

**Recipe for fruit jam :**

Ingredients	Weight (kg)			Final check points
	Mango	Pineapple	Apple	
Fruit pulp	1	1	1	• Pulp- 45%
Sugar	1.2	1.2	1.2	• Sugar- 55%
Citric Acid	6-8 gm	4-6 gm	5-6 gm	• Citric acid - 0.6 to 1.0% of pulp taken
Pectin Powder	10-12 gm	7-10 gm	10-12 gm	• Pectin- 0.5-1.0% of pulp taken
Essence	2 to 4 ml mango	5 ml pine apple	5 ml (apple)	• Final pH-3.6
Colour	3-4 gm orange red	3-4 gm yellow	3-4 gm apple red	• Final TSS-68.5° brix
Preservative (Potassium meta-bi-sulphite)	100 mg	100 mg	100 mg	• Final acidity 0.4-0.6% (as citric acid)
<b>Yield (approx)</b>	<b>2 kg</b>	<b>2 kg</b>	<b>2kg</b>	

- 1. Selection of fruits :** Select fully ripe, good colour, firm, rich aroma fruits. Rinse the fruits and blanch them before use.
- 2. Preparation of fruit/extraction of pulp :** Remove peels, seeds, stone, unedible portion, stalk, and then cut fruits into small pieces. Put into fruit pulper/food processor

and obtain fine, thick pulp, free of fibrous threads.

- 3. Addition of sugar :** As per the recipe given above, weigh the fruit pulp, and take the sugar accordingly. Add sugar at the rate of 0.75 to 1.20 kg per kg of fruit pulp

according to sweetness of the pulp. Weigh the other ingredients also.

**4. Cooking :** Take the pulp in a thick bottom vessel (having copper base), add sugar into it and start cooking on a medium flame; stir it occasionally with long handled spatula or wooden scoop, add citric acid, mix well, check the TSS, finally add the pectin powder in the mixture after mixing it with little sugar, allow it to boil; Do not stir it continuously. Check the TSS by using hand refractometer. It should be around 68.5° Brix. Stop cooking. Add the colour, essence and preservative separately in different containers. Then slowly add, one by one in the whole mixture, stir well. Continue cooking for about 5 minutes.

**5. Judging end point (done stage) :**

**a. Sheet or flake test :** A small quantity of jam is taken from the mixture with the spoon, cool slightly and allow it to fall down, it should flow in a sheet or flake not like a drop or thread.

**b. Total soluble solids (TSS) :** is measured by using hand refractometer (range 58-92° Brix) by taking small quantity of the cooked mass, put it on the prism and observe the reading through eye piece, it should be around 68.5° Brix (%)

**c. Temperature test :** When the temperature of cooking mass reaches to 103-106° C, the jam is considered as ready.

**d. Ball formation test :** Place a drop of cooked jam in a glass of water, if a firm ball is formed at the bottom of glass, it will show that the jam is ready for setting.

**e. On the basis of weight :** the finished jam should be ½ of the initial volume/(wt).

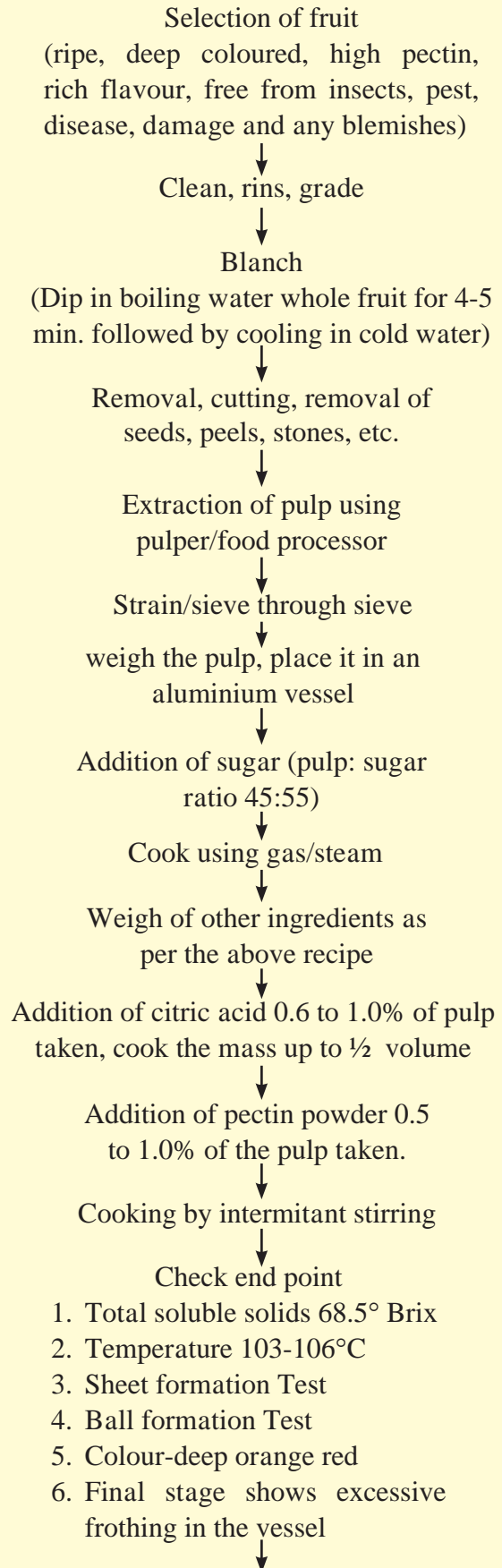


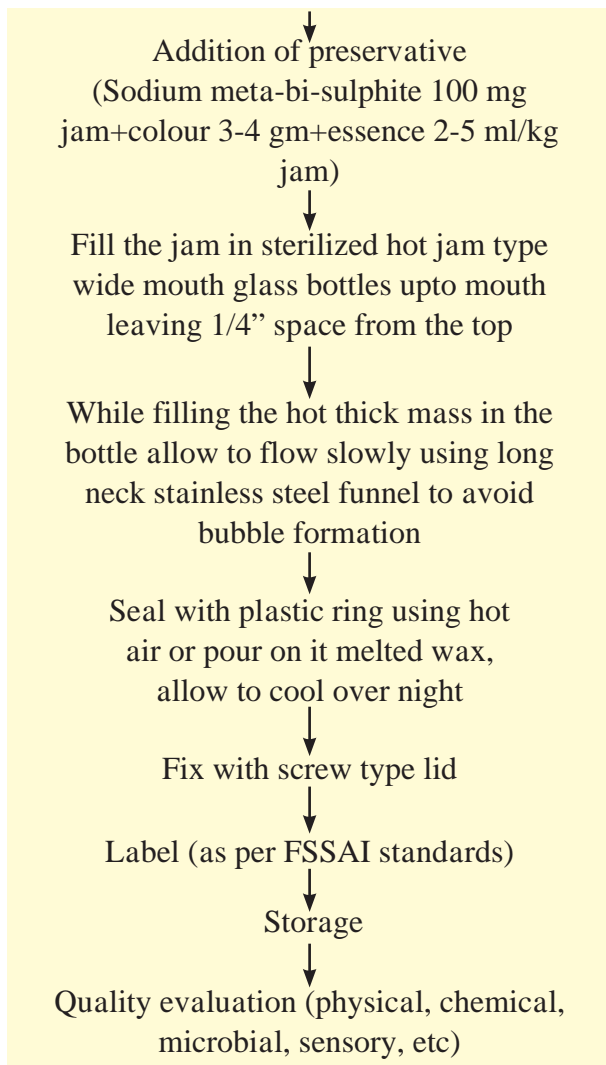
### Remember this

**Analysis of Jam : Determination of invert sugar (glucose) :** by titration method (using Lane and Enyon method) - 50 - 80% degree of inversion.

**Estimation of acidity as citric acid :** 0.5 to 0.7%.

## Process flow chart for preparation of Fruit Jam





6. **Filling and sealing :** Hot jam mass is filled in wide mouth sterilized hot glass bottles upto mouth. Place the hot bottles on a wooden plank while filling the hot jam. Allow them to cool to room temperature. Pour melted wax on the top of the jam at the mouth of the bottles. Cool it for over night or fix with plastic lid on the bottle mouth and seal it firmly using hot gun. Label it and store in a cool dry place.
7. **Quality testing :** Take out the samples periodically during storage period for observing the changes in quality parameters such as physical, chemical, microbial and sensory attributes.

## II. Preparation of Tomato sauce :

Sauces are generally of two kinds and they are the thin and thick sauces. Thin souces

mainly consist of vinegar extract of various flavouring materials like spices and herbs.

Tomato sauce is the thick sauce. A sauce which does not flow freely and which is highly viscous is called a fruit sauce. The thick sauces contain sugar, acid (acetic), and fruit or vegetable pulp. It should contain 1.2 to 3 percent acetic acid to ensure keeping quality. The acidity should not exceed 3.4%. The sugar content may usually vary from 15 to 30 percent according to the kind of sauce made. Usually malt vinegar is used.

In India, tomatoes are grown round the year. A large number of hybrid and selected varieties are grown every year. For processing purpose, the tomatoes should contain TSS > 6° brix, thick pulp, less seed and peels, less poly-phenol oxydase enzymes and deepred tomato colouring pigments with characteristic flavour.

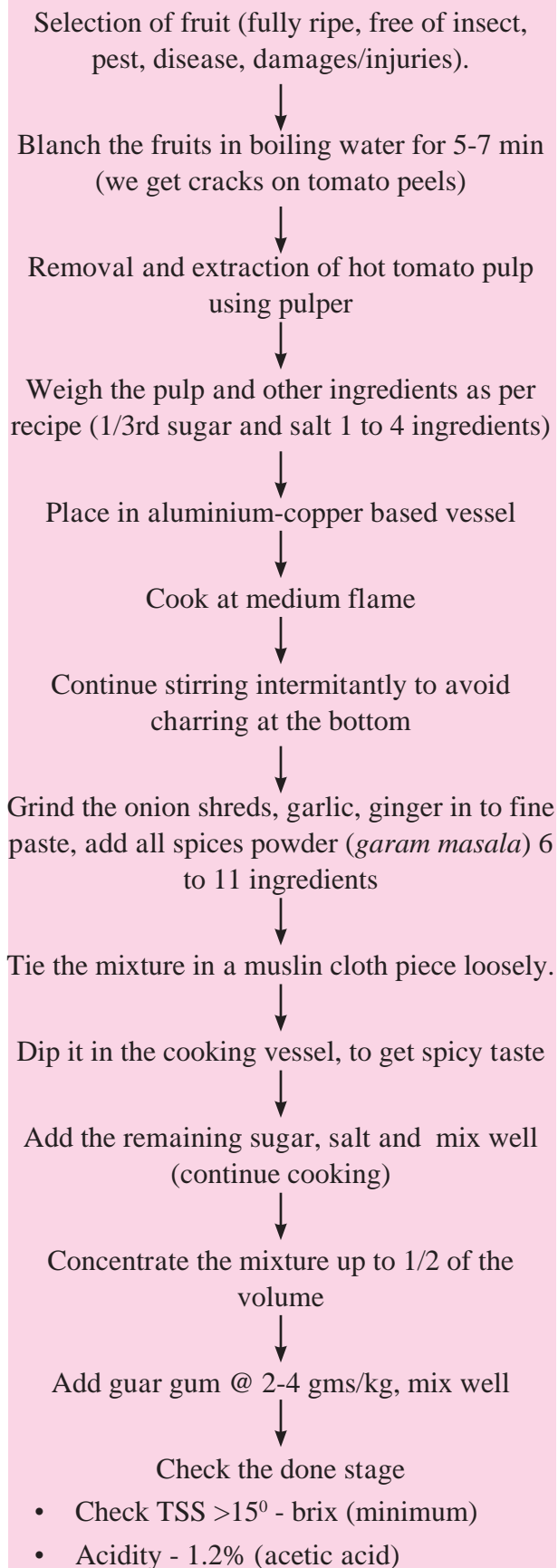
Amongst, the tomato sauce, thick, pungent hot, spicy is preferred by a large population. The FSSAI (PFA) has given the specifications for tomato sauce are as under:

Tomato sauce having acidity 1.2%, TSS > 15° brix free from fungal attack or blemishes, added only fruit pulp, juice, sugar, spices, salt, vinegar, citric acid, acetic acid, malic acid, onion, garlic, permitted colours, etc.

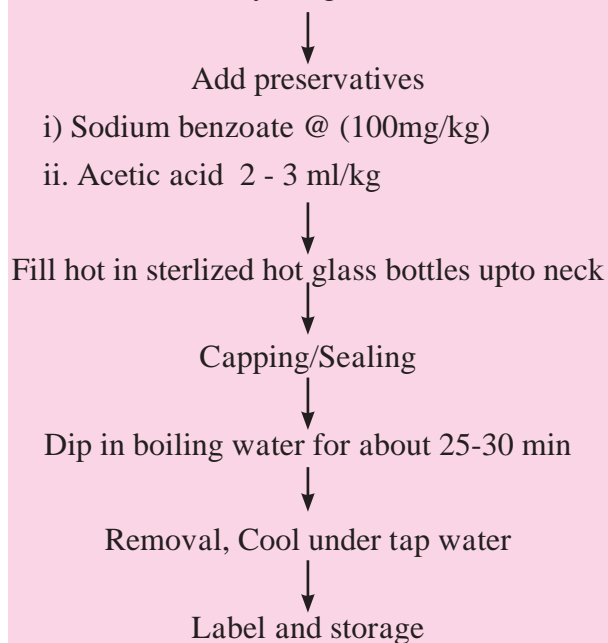


Fig. 14.3 Tomato sauce

### Process flow chart for tomato sauce



- Taste - Spicy, pungent, little hot, sweet-sour
- Salt - 1.3-3.4%
- Colour - Tomato red with bright luster
- Consistency - Thick (thickening agent 0.1-0.2% by weight.)



### Recipe : Tomato sauce

No	Ingredients	Qty
1	Tomato pulp	1.000 kg
2	Sugar	75-100 gm
3	Salt	10-12 gm
4	Chilli powder red	3-5 gm
5	Ginger cut pcs	2-3 gm
6	Onion chopped	5-10 gm
7	Cinnamon	1-3 gm
8	Cardamom (spicy)	3-5 gm
9	Cumin	3-5 gm
10	Black pepper	3-5 gm
11	Cloves	3-5 gm
12	Acetic acid/vinegar	2-3 ml/125 ml
13	Sodium benzoate (Preservative)	100 mg
14	Guar gum (thickening agent)	2-4 gm

**Process** - Follow the steps given in the above flow chart

### III. Pickles

The process of preservation of food in common salt or vinegar is called pickling. Spices and edible oil also may be added to the product. Pickles of various kinds are known well throughout India and many parts of the world. Some of the typical Indian pickles are made from mango, lime, turnip, cabbage, cauliflower etc. and have become popular in several countries. Pickles have also good export market.

Pickles are good appetizers and add to the palatability of a meal. They aid digestion by stimulating the flow of gastric juice. The food value of cucumber pickle exceeds that of eggs, rice, onion and tomatoes.

The Indian pickles are prepared with oil. Mustard, rapeseed and sesamum oils are generally used.

#### Preparation of Mango Pickle :

**Raw Materials :** Raw materials used in pickling should possess certain definite characteristics.

1. **Salt :** The common salt is most suitable, preferably use the crystal salt.
2. **Fruit pieces** Firm, mature, raw mango fruit, light acidity, low in poly phenol oxydases enzymes causing browning, high starch, less sugar.
3. **Sugar** Cane sugar or jaggery can be used a little to taste.
4. **Spices** The spices used depend on the taste and liking of the people. However in general the mix spices used are clove, coriander seed, pepper, mustard seed, cardamom seed, mace, ginger, onion, garlic, cinamon, all spices, etc., in the form of powder-mixture, (commonly known as *garam masala*). Pickles are added with red chilli powder, turmeric powder, etc.
5. **Oil** The oil is used to improve taste, keeping quality and appearance of pickles. Refined oil of any edible seed may be used. Mustard oil is used for red colour; refined cotton seed oil for checking rancidity in

pickles; some portion of oil is used for sautéing of the spices before mixing them in pickles.

6. **Vinegar/ acetic acid** Vinegar contains acetic acid up to 3-5% and used in pickles to improve taste, check the growth of micro-organisms (spoilage), added just before filling the pickle in containers, it acts as preservative.
7. **Preservative** Sodium benzoate is added in pickles for checking the growth of micro-organisms, after dissolving the powder, it forms benzoic acid which has more efficacy against the micro organisms, used @ 250 mg/kg pickle.

#### Recipe - Mango Pickle

Mango (raw) pieces	1 kg
Salt	226 g
Fenugreek ground powder	28 g
Turmeric powder	28 g
Red chilli powder	28 g
Black pepper	15 g
Fennel seed	28 g
<i>Garam Masala</i>	28 g
Acetic acid	1-2 ml
Sodium Benzoate	2-3 g
Mustard	50 g
Asafoetida	5 g



#### Remember this

##### Methods of Preservation :

1. Moisture Removal - Drying
2. Heat Treatment - Pasteurization
3. Low Temperature - Freezing
4. Chemical Preservatives - Class I & Class II
5. Asepsis - Advanced packaging
6. Irradiation - gamma rays
7. Removal of air - Vacuum
8. Fermentation - Acetic acid



**Process flow chart :**

Selection of raw mango



wash, clean, grade



Cut into desired size pieces, weigh



Weigh all ingredients, clean and grind



Take little oil in clean vessel/pan, heat it and add mustard seed, turmeric powder, all *garam masala* powder, fenugreek, mustard dal, stop heating



Put the cut mango pieces, add salt, mix well



Add sodium benzoate, acetic acid (vinegar), mix well lightly, add all oil, again mix



Check the test for sourness, pungency, salt, oil, consistency, colour, etc.



Fill in the sterilized glass/standy pouch/china containers upto neck, press it, store at clean dry place as such for about 25-30 days



Mix lightly and take out sample for cut out test (colour, taste, flavour, consistency)



**Fig. 14.4b Mixed pickle**



**Fig. 14.4a Mango pickle**

## Exercise

### Q. 1 Answer the following question.

#### A. Select the appropriate alternative and complete the following statements.

1. The Govt. of India enacted a comprehensive food act known as .....
  - a. PFA
  - b. ISO
  - c. FPO
  - d. FSSA
2. Preservation of food can be achieved by keeping out micro-organisms by sanitary handling known as .....
  - a. pasteurization
  - b. asepsis
  - c. sterilization
  - d. canning
3. The growth and activity of micro-organisms (spoilage) in tomato sauce is controlled by use of .....
  - a. irradiation
  - b. filtration
  - c. sodium benzoate
  - d. salt
4. In fruit jam making process the preservation action is carried out by using.....
  - a. SO<sub>2</sub> gas
  - b. high sugar
  - c. pectin powder
  - d. citric acid
5. In pickle making preservation is mainly achieved by addition of .....
  - a. salt
  - b. sugar
  - c. colour
  - d. water

#### B. Make the pairs.

Group 'A'		Group 'B'	
1.	Mango pickle	a.	Pectin rich fruit
2.	Tomato sauce	b.	Citric acid
3.	Fruit jam	c.	Sulphuric acid
		d.	Vinegar
		e.	Salt and oil

#### C. Find the odd one out.

1. Jam, Jelly, Pickle, Juice
2. Guava, Papaya, Mango, Tomato
3. Sodium benzoate, Acetic Acid, Citric acid, Guar gum
4. Cinnamon, Cumin, Clove, Sugar
5. Sheet test, Flake test, Ball test, Sweet taste

#### D. Write true or false.

1. The principle underlying in keeping out micro-organisms by sanitary handling is known as asepsis.
2. Preparation of value added products from agricultural commodities will reduce the post harvest losses.
3. Total soluble solids (TSS) in jam preparation is measured by thermometer.
4. Packaging of fruit juices by tetra pack technology helps in preservation.
5. The food products order, 1955 regulation is concerned to fruit and vegetable preserved products, now it is under FSSAI, 2006.

#### Q. 2 Answer in brief.

1. Enlist the various principles of food preservation.
2. List the various methods of preservation of food.
3. What is the full form of FSSAI.
4. Write in brief about quality testing of fruit jam.

**Q. 3 Answer the following questions.**

1. Give the process flow chart for preparation of fruit jam.
2. What are the functions of FSSAI.
3. Enumerate the method of preparation of tomato sauce.
4. List the various ingredients required for mango pickle preparation.
5. What are the various methods of judging end point of fruit jam.

**Q. 4 Answer the following questions.**

1. What are the ingredients used for making fruit jam ?
2. What are the ingredients used for making tomato sauce ?
3. What are the steps in making pickles ?
4. List the various preservatives used in food.

**Q. 5 Answer the following question in detail.**

1. Write the importance of preservation of food by checking/ killing the micro-organisms and enzymes.
2. Write flow sheet for preparation of mango jam.

**Q.6 Answer the following questions in detail.**

1. Explain the principles of preservation.
2. Write in detail complete procedure of jam preparation.



**Activity**

Prepare Pickles at your home.



**Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani**

**Agriculture Science and Technology**  
**Practical Syllabus**  
**Std - XII**

**List of Practicals**

1. Calculation of plant population for given area.
2. Calculation of actual quantity of fertilizers for different crops and calculation of unit value (cost of fertilizer per kg)
3. Practicing different methods of fertilizer application for wheat, paddy and soybean.
4. Practicing layout of sugarcane planting and set treatment.
5. Practicing asexual methods of propagation viz: cutting, layering, budding and grafting.
6. Emasculation and pollination in cotton.
7. Preparation of cropping scheme and calendar of operations.
8. Practicing various nursery operations.
9. Evaluation of seedlings after germination and calculation of seed germination percentage.
10. Seed treatment with chemicals and biofertilizers.
11. Use of computer, internet and smart phones for collection and communication of agricultural information.
12. Preparation of mushroom pickle.
13. Practicing various green house operations.
14. Preparation of jam, sauce and pickles.
15. Practicing post harvest operations in handling of agricultural produce.
16. Study of cost of cultivation of some crops.
17. Awareness in purchasing, storage and application of agricultural inputs.
18. Preparation of crop cafeteria and writing of reports in journal.

**Visits**

- At least four visits from the following list should be conducted.
  - Separate section of visit report should be written in the journal.
1. Visit to tissue culture unit.
  2. Visit to hightech nursery.
  3. Visit to seed processing plant/seed testing laboratory.
  4. Visit to polyhouse.
  5. Visit to Agrotourism centre.
  6. Visit to organic farming unit.
  7. Visit to agriculture produce market committee (APMC).
  8. Visit to allied agriculture enterprises (Sugar factory, Jaggery plant, Dal mill, Oil extraction plant, Processing industry).

**Project work**

Complete any one of the following projects.

1. Preparation of seed album.
2. Collection of farm records.
3. Preparation of seedling for transplanting.
4. Collection of mushroom samples.
5. Preparation of album of diseased plant parts.

**Agriculture Science and Technology**  
**Specimen question paper (Practical) std - XII**

**Time - 3 hrs**

**Marks - 30**

**Q. 1 Identification**

**6**

**A. Identify**

**B. Subquestion**

**Note : In all 6 Specimens should be kept, each carrying 1 mark (1/2 mark for identification and 1/2 mark for correct answer of subquestion)**

**Q. 2 Solve any two of the following.**

**6**

**A. Mathematical problem from practical syllabus**

**(viz. plant population/seed germination percentage)**

**B. Mathematical problem from practical syllabus**

**(viz. quantity of fertilizers/unit value of fertilizers)**

**C. Theoretical question from practical syllabus.**

**Q. 3 Practical exercise (any one)**

**6**

**A. Layering/budding/grafting**

**B. Emasculation and pollination in cotton**

**C. Fertilizer application**

**D. Evaluation of seedlings after germination**

**E. Use of computer or smart phone and internet.**

**F. Layout of sugarcane planting or set treatment**

**G. Seed treatments with chemicals and bio-fertilizers**

**Q. 4 A. Viva-voce - 02**

**6**

**B. Journal - 04**

**Q. 5 A. Project report - 03**

**6**

**B. Visit report - 03**

**Any one report on project and the visit actually given by the student during the academic year.**

## List of Reference Books

1. Introduction to Agronomy and Soil and Water Management - Dr. V. G. Vidya, K. R. Sahasrabudde, Continental Prakashan, Pune - 411030
2. Crop Production and Field Experimentation - Dr. V. G. Vidya, K. R. Shasrabudde, Dr. V. S. Khuspe. continental Prakashan, Pune - 411030
3. Agronomy- S. C. Panda, Agrobios (India) Jodhpur - 342002.
4. Principle of Agronomy - J. Yellamanda Reddy, G. H. Sankara Reddy - Kalyani Publishers.
5. Principle of Crop Production, S. Reddy, Kalyani Publishers, Ludhiyana.
6. Hand Book of Agriculture, I. C. A. R., New Delhi.
7. Principles of Agriculture, Ashok S. Jadhav, Sandip K. Raskar, Raj laxmi Prakashan.
8. Plant Breeding - Principles and Methods - 2005, B. D. Singh, Kalyani Publishers.
9. Agronomy of Field Crops, S. R. Reddy, Kalyani Publishers, Ludhiyana.
10. Seed Technology, Ratan Lal Agrawal, Oxford and IBH Publishing Co-op. Pvt.Ltd., Kolkata.
11. Seed Technology - Dr. Harpal Singh, Tomar, Aman Publishing House, Meerut.
12. Plant Tissue Culture - M. K. Rajdan.
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14. Seed Science and Technology - A. K. Joshi, B. D. Singh, Kalyani Publishers.
15. Principles of Agronomy, S. R. Reddy, Kalyani Publishers.
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17. Seed Science and Technology, Subir Sen, Nabinananda Ghosh, kalyani Publishers.
18. Text Book of Soil Science - A Textbook - V. D. Patil, C. V. Mali, Phoneix Publications Parbhani.
19. Fundamentals of Soil Science, Dr. J. A. Daji, Revised by Dr. J. R. Kadam, N. D. Patil, Media Promoters and Publisher Pvt. Ltd., Mumbai
20. Handbook of Horticulture - I. C. A. R., New Delhi.
21. Manures and Fertilizers - K. S. Yawalar, J. P. Agarwal, S. Bokde, Agri-Horticultural Publishing House, Nagpur.
22. Commercial Production of Horticultural Crops - H. N. Samaddar, Naya Udyoy, Kolkata.
23. Basic Horticulture - Jitendra Singh, Kalyani Publishers, Ludhiyana.
24. Vegetable Crops- T. K. Bose, K. Kabir et. al., Naya Prokash Kolkata.
25. Introductory Ornamental Horticulture - J. S. Arora, Kalyani Publishers.
26. A Class Book of Botany - A. C. Datta, Oxford Publication.
27. Agriculture Science and Technology, Std XI and Std XII, 2018, Maharashtra State Board Secondary and Higher Secondary Education, Pune.
28. Textbook of Crop Production Std XI and Std XII - Maharashtra State Board of Secondary and Higher Secondary Education, Pune
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