TOMATO JUICE EXTRACTION AND JUICE CHARACTERISTICS

Introduction

Tomato *(Lycopersicum esculantum)* belongs to family Solanaceae. Tomato is one of the most popular and widely grown vegetable crops in the world. It stands next only to potato in terms of production. India is fourth largest producer of tomato next only to China, USA and Turkey with an estimated production of 11.98 million tonnes in 2010. In India, Bihar is the leader in terms of area under tomato crops, but Uttar Pradesh leads is production as well as productivity. It is short duration vegetable crops which fit suitably among different dropping system. Important cultivars of tomatoes grown in India include Pusa ruby, Pant bahar, Pusa hubrid-1 & 2 and Arka Saurabh.

Tomato is a very versatile vegetable for culinary purposes. Ripe tomato fruit is consumed fresh as salads and utilized in the preparation of a large number of processed products such as puree, paste, powder, Ketchup, sauce, soup and canned whole fruit. The partially ripened fruits are processed into pickles, chutney and in the recipe of number of traditional cuisines**.** The waste obtained after the juice or pulp extraction i.e. seeds and pomace is also utilized for the extraction of tomato seed oil and lycopene, respectively.

Composition of Tomato

Chemical composition of tomato depends on various factors such as variety, growing environment and package of practice. Besides it, the composition may also vary at different stage of maturity. The composition of tomato is important from the quality point of view as it affects colour, nutrient content, flavour and texture of the both raw as well processed tomato.

Table: Composition of tomato at different stages

Variable	Green (Mature)	Red	Red (Ripe)
Total Solids (%)	6.4	5.8	5.2
Titratable Acidity (%)	0.29	0.27	0.29
Ascorbic Acid (mg/100g)	14.5	23	22
Starch (%)	0.61	0.18	0.07
Reducing Sugar (%)	2.4	3.45	3.65
Pectin (%)	2.34	1.74	1.62

Lycopene (mg/100g)	8	374	412
β-Carotene (mg/100g)	50	10	0
Protein Nitrogen (mg/g dry wt.)	9.44	10.27	6.94

Chemical composition of tomatoes varies at different stage of maturity. Total solid content decreases with maturity from green (mature) to eating ripening maturity due to the conversion of insoluble components mainly starch and insoluble polysaccharides into simple sugars and soluble polysaccharides, respectively. Soluble solids in tomato mainly consisted of sugars, which play significant role in flavour development. The chlorophyll content decreases with concomitant increase in the concentration of lycopene, the major pigment in tomato. The concentration of β-carotene lowered during the maturity and its concentration is more in pink & yellow coloured varieties than red varieties.

Pectin a major cell wall constituent is important for the firmness of fresh tomato and influence the consistency of tomato products. However, the concentration of soluble pectin increased during the ripening because of the higher pectinolytic acidity. Acidity of tomato is mainly attributed to their citric and malic acid content. The average calorific value of tomato varies in the range of 23-25 Kcal/100 g, which is quite low. However, the higher amount of antioxidants like lycopene and ascorbic acid further enhance their nutritional value. They are also very good source of minerals specially magnesium and potassium which have heart healthy role. They also supply copper, iron and sulphur in diet. Oxalate is considered as anti-nutrient component in tomato which may be responsible for stones in kidney and gall bladder by complexing calcium in gastrointestinal lumen. Thus it also decreases the bioavailability of calcium in body.

Nutritional and Therapeutic Effects of Tomato & Tomato Products

Tomatoes are good source of ascorbic acid, which constitutes about 15-20 mg per 100 g of edible parties. The level of ascorbic acid increases with ripening. The concentration also depends on the cultivar and exposure to sunlight. One of the most widely researched components is lycopene, a reddish colour pigment, responsible for characteristic colour of tomatoes. Lycopene is the most effective singlet oxygen scavenger in biological system. Vitamin C, lycopene and carotenoides present in tomatoes are effective antioxidants and have

been found effective in prevention of number of cancers. Lycopene also exhibits similar effectiveness in inhibiting low density lipoprotein oxidation as β-carotene.

Tomato Pulp and Juice Extraction

Tomato juice and pulp are the major primary processed products of tomato which may be utilized for the production of high value added products like puree, sauce, ketchup, chutney, powder etc. All varieties of tomato are not suitable for processing point of view. The varieties which are used for juice and pulp manufacture must possess following characteristics.

1. Deep red coloured varieties are preferred as yellow coloured pigments not only mask the red colour in processed tomato products but these are also susceptible to oxidation resulting in brown colouration.
2. Firm but ripe fruits should always be used as they contain sufficient amount of pectin which is essential for the consistency of the finished products like puree, sauce, ketchup etc.
3. Green coloured and sour varieties should not be used as they will affect the flavour and colour of the resultant products.
4. Tomatoes are also susceptible to microbial decay, hence any infected or diseased fruit should never be used for the manufacture of products as they may pose health hazards.

Fig: Tomatoes suitable for pulp extraction

Preliminary processing of tomato

After selection of suitable fruits, they are washed in running water to remove all adhering dirt, dust, foreign particles including fungal filaments and other microbes. On large scale production plant, rotary washers or trough washers flitted with moving conveyer belt and soft rubber brushes are generally employed.

- **Trimming & sizing**

Tomatoes are trimmed manually with the help of knife to remove green, yellow coloured portion, decayed or infected parts and stalks. The trimming losses may vary from 4 to 17% depending on the selection of raw material. After trimming, tomatoes are cut into 4-6 small pieces of 0.4-0.6 inch and crushed for juice extraction.

- **Pulping or juice extraction**

The tomato juice is probably one of the most widely used juices. Fresh raw tomato juice is most beneficial and because of its alkaline reactions if consumed alone. However, presence of sugar and starch rich foods along with tomato juice make is acidic. The juice extraction may be done either by hot pulping, or cold pulping method.

➢ *21.4.3.1 Hot pulping*

Crushed tomatoes are boiled in their own juice in steam-jacketed stainless steel kettles or aluminum pans for 3 to 5 minutes to facilitate pulping. The crushed or chopped tomato pieces are heated to at least 82�C for 15-20 seconds to inactivate pectic enzymes. On industrial scale heating is usually carried out in rotary coil tanks followed by passing through a plate heat exchanger (PHE) and holding tube to achieve a processing temperature of 104�C to retain at least 90% of the potential serum viscosity in the original fresh tomato. At small scale crushed or whole tomatoes are pressure cooked for 2-3 minutes. Hot pulping or hot break method has following advantages:

- Serum separation tendency in the product is checked, because of more extraction of pectin present in skin and around the seeds. Heat treatment also inactivates the enzymes (pectic enzymes specially polygalacturonase) that may hydrolyze pectin and reduce the viscosity of the juice or pulp. Polygalacturonase is highly heat resistance enzyme that cause splitting of two adjacent galacturonic acid molecules and responsible for softening.
- Juice is quite viscous, heavy bodied and homogenous because of the extraction of pectin and other soluble polysaccharides.
- Thermal treatment partially sterilizes the juice or pulp; thereby it decreases the initial microbial load and product can be kept for longer period.
- Inactivation of oxidative enzymes i.e. ascorbic acid oxidase, prevent loss of vitamin C.
- More juice yield as compared to cold pulping.
- Juice or pulp obtained by hot pulping process is deep red and attractive in colour. It is because of the release of pigments located within the cell vacuoles due to heating.

➢ *21.4.3.2 Cold pulping*

In cold pulping or cold break method tomatoes are scalded to facilitate the separation of skin before chopping. Tomatoes are crushed or chopped at temperature less than 66�C and allowed to fall into a holding tank, where they

remain for few minutes. During this period the native cell wall hydrolyzing enzymes of pectinolytic enzymes of the tomatoes are liberated and catalyze the various hydrolytic reactions to release the cellular components. The cold break juice is better in terms of flavour, colour and nutrients mainly vitamin C, but the juice is quite prone to spoilage and quick processing of the extracted juice is necessary. However, following defects are found to be associated with this method:

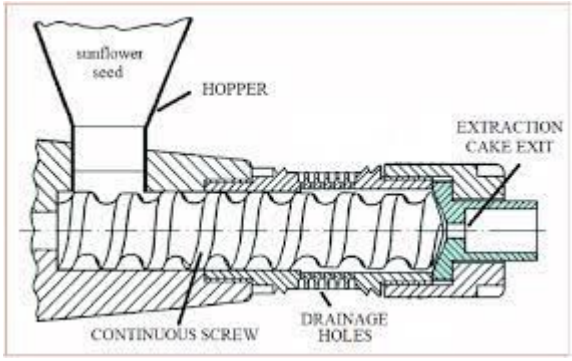
- Extraction of juice from the interior of cell requires higher pressure. Hence often juice yield become low, higher pressure cause extraction at juice around the seeds, which is more acidic and less sweet.
- Inferior colour (lighter) because of the less extraction of pigments from the skin
- Poor microbiological quality as comparison to hot break juice.
- Less nutrition due to oxidation of vitamin C resulting in loss.
- Cold extraction results in insufficient extraction of pectin and other polysaccharides that may adversely affect the viscosity or consistency.

- ***21.4.3.3 Equipments for pulp or juice extraction***

Two different types of machines are used to extract the juice or pulp from the tomatoes namely Continuous spiral press and the Cyclone or pulper.

- *Continuous spiral press*

The equipment consists of a long spiral screw which presses the tomatoes against a tapered screen of fine filter of 25 mesh size. The crushed tomatoes are fed through hopper and conveyed by the rotation of screw which normally rotates at a speed of 250 rpm. The low speed further disintegrate the tomatoes and free flowing juice and small pulp particles passed through the screen whereas skin and seeds are retained. During the extraction of juice or pulp care is taken to avoid incorporation of air and minimize the oxidative damage.



Scheme of continuous screw press

- *Cyclone or pulper*

Juice can also be extracted by passing the crushed or chopped tomatoes through a cyclone or pulper. The machine consists of perforated cylindrical screen with apertures on about 25 mesh size and one rotating shaft which moves at very high speed to broken down the tomatoes into very small sized particles. The free flowing juice and smaller pulp particles are passed through the screen and separated out. In this method the insoluble solids in the juice are very finely divided and remain in juice for longer period. However, the use of cyclone results in incorporation of air which accelerate the various oxidative reactions.

In any method of juice or pulp extraction not more than 60% of fruit should be recovered as juice or pulp other it may affect the flavour and appearance of the resultant juice or pulp adversely.

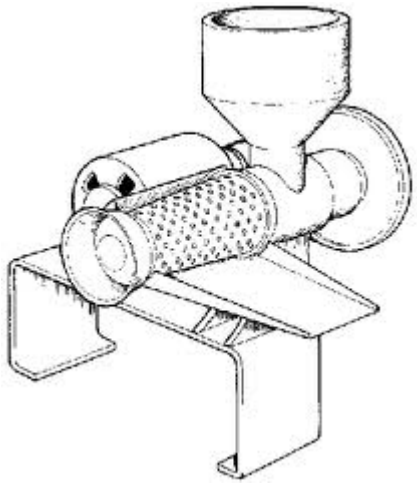


Fig.: Schematic diagram of tomato pulper

Processing of Juice or Pulp

As per FSSA definitions thermally processed tomato juice means the unfermented juice obtained by mechanical process from tomatoes (*Lycopersicum esculentus* L) of proper maturity and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage. The juice may have been concentrated and reconstituted with water for the purpose of maintaining the essential composition and quality factors of the juice. The product may contain salt and other ingredients suitable to the product. The product shall be free from skin,

seeds and other coarse parts of tomatoes. The product shall have pleasant taste and flavour characteristic of tomatoes free from off flavour and evidence of fermentation. The product shall conform to the requirements of total soluble solids (TSS) m/m free of added salt to be not less than 5.0 percent. The product may contain permitted food additives as specified by FSSA. The juice thus obtained is filtered to remove undesired portions like skin fractions, seeds by passing through filter (metallic or polymer vibrating perforated screen with desired pore size). The filtered juice is de-aerated immediately to prevent the oxidative losses. The additives or ingredients like sugar, citric acid or salt is added to improve the flavour of the juice. On an average juice should have TSS content of 5.66 per cent at 20�C. Juice may further be filled into bottles, cans using filling machine. The fill machines are adjusted to give minimum headspace as possible in order to check oxidative deteriorations. The cans are hot filled at about 82-88�C followed by processing at 121�C for not less than 0.7 minutes, followed by cooling of containers by spraying cold water jackets.

In case of pulp homogenization is suggested to retard the tendency of serum separation in juices and other processed products. Tomato juice or pulp is very much susceptible to spoilage by mould, yeast and bacteria. The pH of the tomato juice and pulp varies in the range of 4.0 to 4.4. The major risks of spoilage of from spore forming species other than *Clostridium botulinum* mainly *Bacillus coagulans* among the aerobes and *Clostridium pasteurianum* and *Clostridium thermosachharolyticum* among anaerobes.� The spoilage of tomato juice is characterized by a peculiar off-taste and odour known as ﷺflat sourﷺ.

TOMATO PUREE, PASTE, SAUCE AND KETCHUP

Manufacturing of Tomato Puree and Paste

The pulp which is obtained by hot or cold break method is concentrated to manufacture puree and paste. Fully mature and deep red coloured tomatoes are preferred for the manufacture of tomato puree and paste.

Tomato Puree

Tomato juice or pulp as obtained by cold or hot extraction method is concentrated to about 9.0 percent to 12.0 percent total solids to prepare tomato puree. Commercial tomato puree can be defined as concentrated tomato juice or pulp without skin or seeds, with or without added salt and containing not less than 9.0 percent salt free tomato solids, is ﷺmedium tomato pureeﷺ. Further concentration to 12.0 percent solids will yield ﷺheavy tomato pureeﷺ.

Tomato Paste

Tomato paste can be defined as concentrated tomato juice or pulp without skin and seeds, and containing not less than 25 percent of tomato solids. If the tomato paste is further concentrated to a tomato solid levels of 33 percent or more then it is called as concentrated tomato paste. The manufacturing technology for the production of tomato puree and paste is outlined in Fig. 22.1.

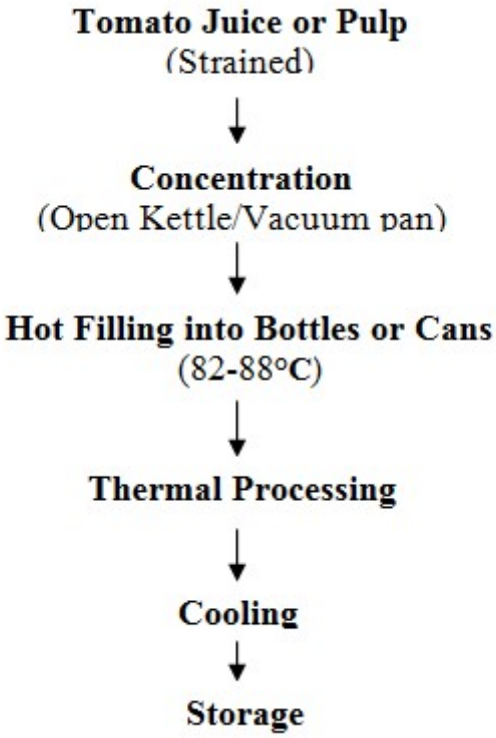


Fig: Process flow diagram for tomato puree or paste manufacture

Fig: Tomato puree (A) and Tomato paste (B)

Tomato juice or pulp is strained or filtered to remove portions of skin, seeds and large coarse pieces to get uniform juice or pulp. The juice or pulp is concentrated in open kettle or vacuum kettle to evaporate water and the process of evaporation in case of puree is continued till the volume reduced to equal or one-half of original. The end point is determined by the hand refractometer to measure the total soluble solids and expressed as degree Brix. Alternatively it can also be determined by using specific gravity bottle or by drying the juice or pulp under vacuum at 70°C. The puree of desired total soluble solids is then filled into cans (temperature of filling 82-88°C) and processed in boiling water for 20 min. The processed cans are cooled immediately either by dipping them in cold water or sprinkled with cold water. The cans are then stored in dry and cool place.

For the manufacture of tomato paste, tomato juice or pulp is first concentrated in open steam jacketed kettle to total solid levels in the range of 14-15 percent and subsequent concentration is carried out in vacuum pan. During cooking in open kettle common salt, basil leaf or sweet oil of basil leaf may also be added to prevent the excessive foaming, burning and sticking. In vacuum pan, the water

present in pulp or juice starts evaporating at 71C. It assists in retention of bright red colour and flavour. The removal of air also check any oxidative reaction that may adversely affect the nutritional value i.e. vitamin C. For sterilization of the product, vacuum is removed and the temperature is raised to 100C and held at that temperature for about 10 min.

Technology of Tomato Ketchup and Sauce

Among the tomato products, in India tomato sauce and ketchup are very popular and are being manufactured on an increasingly large scale. It is one of the simplest ways of conserving the tomato solids. As per FSSA standards Tomato ketchup and sauce means the product prepared by blending tomato juice/puree/paste of appropriate concentration with nutritive sweeteners, salt, vinegar, spices and condiments and any other ingredient suitable to the product and heating to the required consistency. Tomato paste may be used after dilution with water suitable for the purpose of maintaining the essential composition of the product. The finished product should contain not less than 25.0 percent total soluble solids (salt free basis) and acidity not less than 1.0 percent as acetic acid. The product should also meet the given microbiological criteria (Table 22.1).

Table 22.1 Microbiological criteria for tomato ketchup and tomato sauce

Tomato Ketchup and Tomato Sauce	Mould count	Positive in not more than 40.0 percent of the field examined
	Yeast and spore count	Not more than 125 per 1/60 c.m.m
	Total plate count	Not more than 10000 per ml

Tomato ketchup and sauce can be made from freshly extracted juice or pulp or using tomato puree or paste. Strained tomato juice or pulp along with spices, salt, sugar and vinegar is cooked or concentrated to the extent that ketchup and sauce contains not less than 12 percent tomato solids, 25 percent total solids and minimum acidity as 1% acetic acid. The TSS content in tomato ketchup should be 25-29 for grade C, 29-33 for grade B and over 33 for grade A.

Basically there is no difference between tomato ketch-up and tomato sauce. Tomato sauce has thinner consistency and it is blended with juice or pulp from other vegetable sources including potato puree, cucumber juice or carrot pulp. In the manufacture of tomato ketchup following steps are involved:

Selection of raw material

Careful selection of tomato for the manufacture of tomato ketchup is very crucial step as it may affect the quality as well as shelf-life of the finished product. The criteria for selection include maturity, freedom from blemishes and defects. Ripe deep red coloured tomatoes with higher TSS and pulp provide a better quality product. Pectin content and pigmentation are two important parameters determined the finished product quality.

All green and yellow coloured portions should be removed. Chlorophyll and Xanthophyll present in immature fruits, upon heating form brown coloured compound pheophytin that may adversely affect the acceptability of the product. Flavour of the product also gets affected, if green tomatoes are used.

Extraction of pulp or juice

The pulp or juice could be extracted by using hot or cold pulping method. However, hot pulping method yields pulp with higher proportion of total solids, lycopene; pectin content and of good microbiological quality. The freshly extracted pulp or juice as well as preserved pulp or puree or paste may be used as starting material. Use of puree or paste of suitable total solid level produce ketchup of uniform quality and also ensure consistency from batch to batch.

Juice standardization

Freshly squeezed juice is a thin, watery fluid and its specific gravity varies with the kind of tomato and duration of boiling. Its T.S.S. should not be below 5.66Brix. In case of tomato puree or paste these are diluted to desired total solid level before ketchup preparation. After standardization of juice or pulp total solid the ketchup or sauce is manufactured by the process as outlined in Fig. 22.2.

Fig.: Process flow diagram for tomato ketchup or sauce manufacture

Fig. 22.4 Tomato ketchup and tomato sauce

Addition of ingredients

Spices

The spices should be of good quality and they should be added in the proper proportions to give an agreeable taste and flavour to the product. No single spice dominates the natural flavour of the tomato. The spices which are preferred in ketchup manufacture include red chili, black pepper, nutmeg, clove, cinnamon, cardamom, mace and cumin. Beside these spices seasonings like onion, ginger and garlic may also be used in ketchup recipe. While adding spice certain precautions are recommended to produce excellent quality ketchup or sauce.

- Red chili powder, spices, onion and ginger should be tied loosely in bag for better diffusion of flavoring principles in ketchup.
- The head portion of clove should always be removed before its grinding as it may lead to black neck defect in ketchup.
- Normally garlic is not preferred seasoning in ketchup or sauce manufacture as its flavour may predominate over other spices.

- Essence of clove, cinnamon and cardamom is preferred in place of using coarsely ground powder because of the convenience of use and better flavour note in finished product.

The spices may be used in the following way during the manufacture of ketchup or sauce.

Bag method

The coarsely ground spices are tied loosely in a muslin cloth bag and the bag placed in the tomato juice during boiling. The bag is pressed intermittently to release the flavouring component during processing. The proportion these spices should be standardized in such a way that they should not affect the colour of the resultant product and does not impart bitterness. This bag can be used for second batch also. This method has following drawbacks:

- By chance opening of bag may spoil the whole batch. Even if we want to remove these, spice particles by passing it through sieve, it may darken the product.
- Incomplete extraction of flavouring component, so, flavour of ketchup may vary from batch to batch.
- Some of the volatile constituents may get lost during boiling.

Still bag method yield ketchup of superior quality and it is most preferred for ketchup or sauce preparation at small scale or batch methods. The spice bag may also be used for subsequent batches and used spices may also be in pickle preparation.

Use of essential oils

An essential oil is a concentrated hydrophobic liquid containing volatile aroma compounds from spices. They are extracted by the process of distillation or solvent extraction. The Essential oils of spices contain only the volatile substance of the spice and devoid of tannins, hence the colour and flavour of ketchup is not affected. These can be easily blended and precision in terms of percentage can be made. However, they lack the true aroma of the whole spice. The actual amount of essential oil for raw spice is mentioned below.

Table 22.2 Essential oil content in different spices

S. No.	Spice (100 kg)	Equivalent Weight of Essential Oil (kg)
1	Cinnamon	0.5

2	Clove	1.5
3	Mace	3.5
4	Pepper	1.0
5	Cardamom	3.0

Use of oleoresins

Oleoresins are pure and natural extracts of spices, obtained by solvent extraction. These concentrated extracts contain all the flavour components, be it volatile oils or non-volatile resinous fractions. These are the resins of active flavouring component in some solvent. The active flavouring molecule is extracted with a suitable solvent and it can provide the full flavour profile of the raw spice with quick release of the flavour. Application of oleoresins is advantageous in commercial production of ketchup or sauce. The only limitation while using oleoresin is the cost of production. Oleoresins are added few minutes before the final boiling during the manufacture of ketchup or sauce.

Use of extracts

Spice extract is prepared on large scale by steeping or boiling spices in vinegar. The aroma component of the spices gets extracted in vinegar and vinegary extract may be used in place of whole spice. It assists in maintaining the same taste and aroma and also standardizes the proportion of spices in the recipe. Nowadays, it is one of the most widely accepted methods of spice addition.

Sugar

Sugar is mainly used to adjust the sugar-to-acid ratio of the ketchup or sauce. Sugar may be added in the form of granular sugar, corn syrup and other syrups are used. However, granular sugar is most preferred one. About 1/3rd of sugar is added in the initial stage of boiling. This help in preserving the natural colour of the product. Rest of the sugar is added minute before final concentration is reached. Initial addition of sugar will adversely affect the colour of the product as cooking of the product with higher amount of sugar under acidic conditions flavour brown coloured ﷽Furfural﷽, Commercial level, sugar level varies between 10-26%. Higher amount of sugar may impart higher sweetness which is not liked by consumers.

Common salt

Salt bleaches the colour of the tomato and also dissolve to some extent copper from the processing equipment. It is, therefore, desirable to add towards the end point of the process. Range of common salt varies between 1.5 – 3.5%, salt is added to enhance flavour of the product and exert preservative action to a lesser extent. Salt of very high purity is preferred for the ketchup manufacture. Salt also counteract the highly acidic flavour of the tomato pulp.

Vinegar

Well matured salt-vinegar, cider vinegar or malt vinegar may be used as acidulant in the product. However, these vinegars are not colourless; hence they may affect the colour of the finished product. Vinegar contains not less than 5 percent acetic acid. On industrial scale commercially available glacial acetic acid is preferred because of the following reasons.

- Lower cost as compared to malt, or cider or salt vinegar
- Glacial acetic acid is 100% acetic acid; hence it will have lesser effect of heating.

Vinegar is always added towards the end of the process in ketchup or sauce manufacture. Since it is a volatile product most of the acid will lose during cooking. Ketchup contains 1.25-1.50 percent acetic acid. Vinegar contributes towards the flavour as well as microbial stability of the ketchup.

Thickening agent

Insufficient quantity of pectin in tomato juice, puree or paste invariably results in serum separation in ketchup during storage. Ketchup prepared by cold pulping process contains very less amount of pectin due to incomplete solubilization and extraction of pectin. Likewise using variety with low pectin content may also necessitate addition of certain thickening agents. Hence, pectin (0.1 – 0.2%), corn starch (1%) and other hydrocolloids may be added to control this problem. Xanthan gum is an ideal thickener for this type of products because of its acid stability and pseudoplastic flow properties it imparts. The glass or sheen, which xanthan gum imparts to these sauces or ketchup is another appealing factor for the consumer. Pectin may also be added @ 0.1-0.2 percent by weight of finished product in clear juice or pulp to check the problem of serum separation and to also increase viscosity.

Table: Recipe for tomato ketchup

S. No.	Ingredient	Amount
1	Tomato pulp	1 kg

2	Sugar	70 gm
3	Salt	10 gm
4	Chopped onion	1.5 gm
5	Chopped garlic	1.5 gm
6	Red chili powder	0.5 gm
7	Cumin, Cardamom	0.40 gm each
8	Clove (headless)	1.5 gm
9	Cinnamon	1.5 gm
10	Vinegar	10 ml

Cooking & concentration

The tomatoes juice along with other ingredients is cooked and concentrated to get the desirable flavour, uniform taste and fine thickness or body. The cooking of ingredients may be carried out in open jacketed kettle or vacuum concentrator. The cooking continues till the concentration reached 25 percent TSS. However, concentration of 28-30 percent total solid is ideal as further increase may adversely affect the flavour of the product. However, to improve the stability of ketchup slightly higher amount of sugar, salt and vinegar is added.

Bottling & Packaging

The ketchup after attaining the desired total solid level and consistency is finally passed through a finisher to remove any tomato fibre, seeds and any other suspended solids. The Ketchup or sauce after cooking should be bottled hot at 85-88�C to prevent browning and loss of vitamin during subsequent storage and distribution. Hot filling of bottle also assist in creation of vacuum in the headspace during the cooling of ketchup. The crown cork used for ketchup bottle should be lined with polyvinyl chloride (PVC) to prevent the contact of ketchup with the metallic portion to avoid the �black neck� formation. However, nowadays sauce and ketchup is also packed in laminated flexible packaging materials consisted of polyethylene (PE), polyester (PET) and aluminum. These polymers may be co-extruded in different combinations to get the desired functional and mechanical properties. Sauce and ketchup require protection from oxidation and moisture migration/ingress. Moreover, certain squeezable bottles are also used for the packaging of these products. Bottled and packaged products are stored under ambient temperature (30-35�C) under dry places.

Pasteurization

Although, hot filling of the ketchup in bottle is considered safe for consumption and have sufficient shelf-life, but still come manufacturers prefer further thermal treatment. The hot filled bottles are pasteurized in hot water (85-88�C) for 30-35 minutes. Care must be taken to cool the bottle immediately after pasteurization to avoid the degradation of nutrients and over-processing. Shelf-life is also enhanced by using preservatives.

Defects in Ketchup

The two most common observed defects in ketchup are: serum separation and blackening specially around the neck. The latter defect is referred as ﷺBlack neck defectﷺ. The tannins present in spices get extracted into the ketchup and when these phenolic compounds come in contact with iron leached out either from processing vessels or from the closure of ketchup bottles, they form ferrous tannate. This compound undergoes oxidation and form ferric tannate and it is a black coloured compound. To check it one should not use iron or copper utensils and headless clove should be used. The inner lining of bottle cap should be of PVC. Problem of serum separation as already been discussed in Section 2.4.5. Among the microbiological problem mold growth is the most serious one. Microbial growth can be taken care by adding chemical preservatives specially benzoic acid. Benzoic acid is added in the form of its sodium or potassium salt because of almost 54 times higher solubility of salt as compared to benzoic acid. As per FSSA guidelines the maximum permissible limit of benzoic acid is 750 ppm.

Fig.: Black neck defect in tomato ketchup

NOVEL TOMATO BASED PRODUCTS

Technology of Tomato-Chili Sauce

Tomato sauce is equally popular like tomato ketchup and there is lot of scope of innovation in formulation and manufacturing process to develop newer variant of it. Several such commercial preparations like Tom-chi (Tomato-Chili Sauce), Tom-Imli (Tomato & Tamarind sauce) etc; are available in Indian market. The purpose of developing such novel products is to utilize tomato, offer new products to consumer and diversify the product profile. Tomato sauce is slightly thinner in consistency than tomato ketchup and may contain certain thickening agents derived from vegetable starch (potato, cassava) or cereal (maize). It also contain higher amount of acetic acid i.e. around 1.60 percent to improve the keeping quality. The amount of sugar is usually higher (15-23 percent) to counteract harsh acidic taste and flavour. The concentration of spices is kept less as compared to ketchup.

The manufacturing technology for the tomato-chili sauce is similar to as discussed for tomato ketchup. The green chili is pureed by hot break method and seed as well as coarse fibrous portions are removed. The pureed chili is added in the formulation and ratio of sugar-acid-pungency is maintained in such a way that resultant product provide the flavour sensation of all the three in balanced way. Similarly, in tomato-imli sauce, the tamarind pulp is added along with tomato pulp and to balance more acidity slightly higher percentage of sugar is added. These novelty products are popular among all age groups and consumed with snacks.

Dried Tomato Products

Tomatoes are quite perishable in nature and can be processed as dried product for value addition. Tomato slices can be dried by using tray or tunnel drying process or alternatively tomato pulp of juice may be spray dried to yield tomato powder of excellent quality. Drying process increases their availability round the year in convenient form.

Dried tomato slices

Dried tomato slices are versatile ingredient and find its application in various food formulations. Tomatoes of good quality are after through washing are blanched either in plain water or in 2.5% salt solution for 1 min. These blanched tomatoes are dropped in cold water to quickly cool the product. This also helps 1.5 cm thick slices, and excess juice is drained off. Tomato slices are dipped in 2.5% gelatinized

starch containing 5% potassium meta-bisulphate for 9 min. They are spread over perforated or aluminum trays. Drying is carried out at 65-70 C in a tray drier till the moisture reached to 4.5%. These slices may be packed in polythene bags or grind as powder (Fig. 23.1).

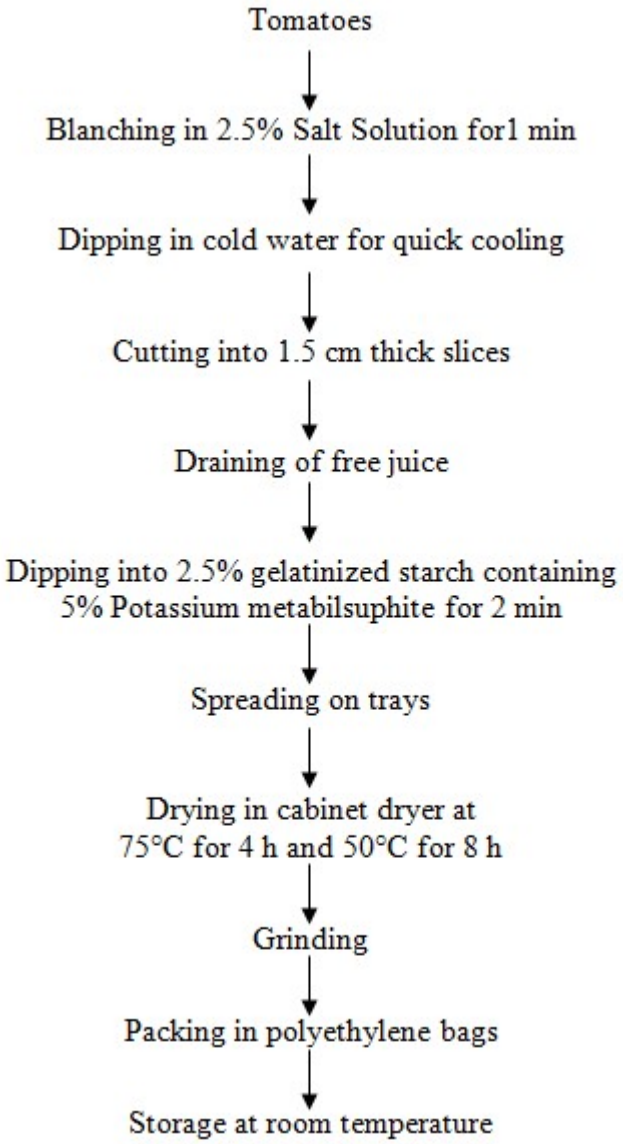


Fig. 23.1 Tray drying process for tomato slices

Tomato powder

Tomato powder preparation is another technique for the preservation of tomato solids during off-season and offer convenience to consumers. The powder may be used in formulation of other processed products like culinary recipes or can be reconstitute in the form of juice or used as starting material for the manufacture of secondary products like sauce, ketchup and chutney. The tomato powder can be manufactured by using tray drying, foam mat drying or spray drying process.

The powder obtained by different methods also varies in their properties mainly colour, nutrients and reconstitution.

For the manufacture of tomato powder whole tomatoes are cleaned, washed and surface moisture is allowed to evaporate. The juice is extracted by hot pulping methods and pulp is filtered to obtain pulp free juice which is subjected to vacuum concentration. The concentrated juice is mixed with foaming agent to form foam which is dried by using hot air. The dried powder is cooled, conditioned and ground in the form of powder.

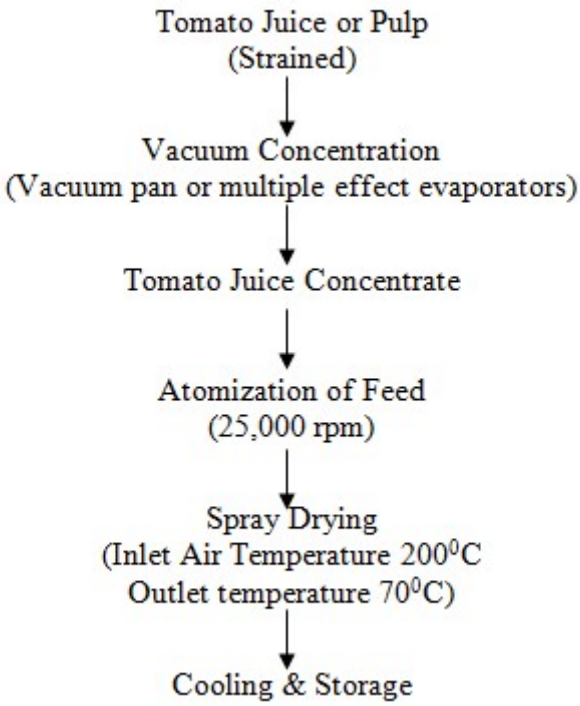


Fig.: Spray drying process for the preparation of tomato powder

The spray drying process for the manufacture of tomato powder is outlined in Fig 23.2. The tomatoes with thick walled, bright red colour, high solids and high pectin content are the best for dehydration. The juice is extracted by hot break method and may also be subjected to enzymatic treatment to improve the recovery of juice, solids and colouring pigments. Seeds and skin pieces are removed prior to particle size reduction. The juice is concentrated in vacuum pan or double effect evaporators to desired total solid level. Maltodextrin (10 DE @ 10%) and SiO_2 (@ 1%) are added in concentrated juice to improve the colour and reconstitutional properties of the powder. The atomization speed of 25,000 rpm and inlet air temperature of 200�C is recommended for obtaining good quality tomato powder.

Colour of tomato powder depends on the lycopene content which is affected by thermal treatment. Therefore, optimization of feed rate, temperature of inlet and outlet air, additives and atomization speed determine the extent of thermal damage and quality of powder. The powder can be packaged in oxygen and moisture impermeable films. Further it can be also packed under vacuum for prolonging the shelf-life.

Whole Tomatoes in Sauce

This product is a new kind of product. In this product whole tomatoes are preserved in their natural form, which is quite appealing to the consumers. The tomatoes dark red in colour, firm and free from any defect, are selected, washed thoroughly in water. The uniform elliptical shape or round shaped tomato varieties are preferred. These tomatoes are blanched in boiling water for 230-60 seconds and quickly cooled to avoid softening. They may be placed in 5% brine solution or 20% sugar solution or a combination of these two to remove excess moisture for 230 min. Alternatively, they may be surface dried in a stream of hot air (45�C). The dipping solutions may contain calcium salts to improve the firmness of the product. The pH of the covering liquid tomato may be adjusted to below 4.5 by adding citric acid and thermally processed at 80-85�C for 20-30 min., cooled quickly. The glass jar should be air tight.

Whey-Tomato Soup

Soups are served as appetizers before meals as they stimulate the secretion of gastric enzymes that leads to feeling of hunger. In market a large number of ready-to-make soup mixes are available to suit the palate of consumers. But certain additives in such soups mixes are considered harmful particularly to children. Moreover apparently they do not seem to provide quality nutrients and utilization of whey for soup preparation is attractive possibility.

The process for the manufacture of whey based soup involves blending of vegetables in whey and cooking of corn flour followed by heating (Fig. 23.3). The time-temperature combination of cooking of vegetables, corn flour and seasoning is important for dispersion of vegetables, gelatinization of starch and flavour perception of soup respectively. The developed product could be stored for a week under refrigeration and UHT treatment can be adopted to improve the shelf-stability. The soups can be packaged in retort pouches as well and processed in boiling water bath (85-90�C) for at least 30 min.

Cheese whey is preferred for the manufacture of vegetable soups than paneer whey, the latter being acidic. Whey based soups have been reported to be more

viscous as compared to water based most probably due to gelation of whey proteins on heating. Whey based soups require less amount of salt, thickener and fat.

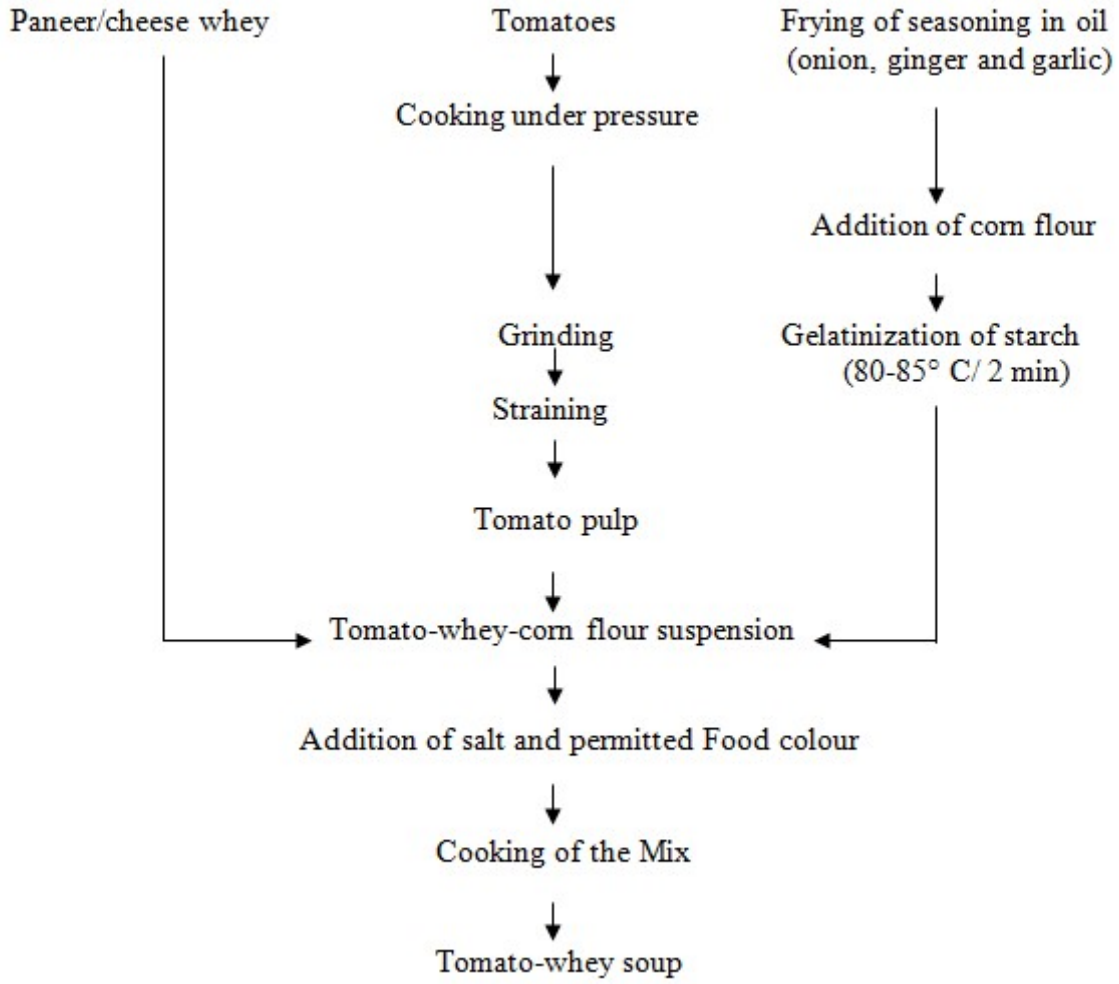


Fig.: Manufacturing process for whey-tomato soup