Plant Sanitation

Plant sanitation in a baby food manufacturing operation is a very specialized procedure. It is headed by a Plant Sanitarian whose sole job is to assure plant management that all necessary procedures are being followed in order to maintain the baby food plant in excellent sanitary condition. To be effective in a baby food operation, this individual must have a high company rating and have the backing of the top management in the corporation.The Plant Sanitarian must be licensed in his state to carry out the proper functions of pest control, particularly in the area of insect control. He must be current on all laws of the state and the federal government in order to use the proper materials for maximum effectiveness within the law. Many residual insecticides, though very effective, are not permitted for use in areas where food materials are stored or processed. In such areas, of course, it is necessary to use non-residual materials such as pyrethrins as a spray or fog.

It is also the sanitarian's responsibility to assure that the plant is free from rodents. The first line of defense is keeping on constant alert within the plant as well as outside the plant. Traps and warfarin are the major materials used in combating rodents.

Another responsibility of the sanitarian is general plant housekeeping. It is up to him to see that action is taken if there are areas of poor housekeeping present anywhere in the plant or around the grounds.

One of the most important plant sanitation activities is plant clean up. That is the daily clean up of plant production equipment. A good sanitarian is up to date on all materials that are used, as well as the latest procedures available. He works with the clean up crew helping to implement the use of new materials and new methods. It is also his responsibility to check on the effectiveness of routine clean ups. Several techniques are employed in this effort, including working with the clean up crew, as well as conducting post clean up inspections.

In addition to the responsibilities mentioned above, the plant sanitarian is frequently required to help out in other areas, such as evaluating clean up problems when contemplating purchase of new pieces of equipment.

Baby food manufacturers must stay current with all the latest trends in food processing and packaging, consumer needs and wants, marketing, government regulations, agricultural production of raw materials, quality control, and, in general, food research.

ACKNOWLEDGEMENTS

The author acknowledges with thanks the contributions made to the preparation of an earlier edition of this chapter by William W. Fisk, Gerber Products Company, and Ellery Parker, Beech-Nut Nutrition Corporation for this edition.

CHAPTER 12

Tomato Products

Canned tomatoes are covered by USDA Standards for Grades and by FDA Standards of Identity, Quality, and Fill of Container.

GENERAL CANNING GUIDELINES

General Description of Operations

Good Manufacturing Practice regulation for low-acid foods exempts tomatoes and tomato products having a finished equilibrium pH of less than 4.7. This pH includes a safety factor of 0.2 pH unit. Research has shown that in tomato products a finished equilibrium pH of less than 4.9 will prevent the outgrowth of *C. botulinum*. Therefore, tomato products with a finished equilibrium pH value of less than 4.7 are not considered low-acid foods for the purposes of the GMP regulations.

Excellent mechanical means are available for the canning of tomatoes. See the figures (charts) later in the chapter for plant arrangement. Machinery manufacturers will gladly furnish details and plans.

The tomato is most often classed as a vegetable though the part of the plant canned is a true fruit. It is cultivated in nearly every section of the United States, with California and Ohio showing increasing trends in tons produced for processing, and is canned over a wider area than probably any other product. The U.S. produces over 50% of the world production for processing. California produces more than 85% and Ohio about 6% of the total tons for processing. Besides being canned whole, it is used as the most important ingredient in soup, ketchup, as tomato juice, in pizza sauce, spaghetti sauce, sauces for baked beans and fish, and salsa. The U.S. pack distribution for 1990 is estimated as follows: sauces 35%, paste 18%, canned form 17%, ketchup 15% and juice 15%. The fresh fruit forms the basis of many salads and is in such great demand that it is grown in the South and in Mexico to supply the winter and early spring market. It is even grown extensively in greenhouses. Tomatoes are recognized as one of the best sources of vitamin C.

Varieties

Contact the local Agricultural Extension Agent, other agricultural authorities, or a seed company on varieties best suited for canning in the specific area where the commodity is to be produced.

The varieties most desirable for canning should produce "coreless", medium sized fruit of smooth contour, meaty and with small seeds. They should have a clear red color, be ripe to the base and shoulders, and have a good characteristic flavor. Tomatoes which are of light color, yellow or yellowish green, may be good as far as flavor is concerned, but they do not appeal to the eye, and are graded low by U.S. Standards for Canning. Tomatoes of irregular shape may be of good quality and yield well, but cause too great a loss in peeling.

Gould (1992) suggested considering the following guidelines when developing and using new varieties for processing.

1. Varieties should be uniform in setting fruit and in ripening with ability to set fruits over a wide range of temperature and climatic conditions.
2. Varieties should be fully resistant to all tomato diseases, insects and disorders.
3. New cultivars must be adaptable to mechanical harvesting and bulk handling.
4. All tomatoes for processing must be free from blossom end scars and cracking.
5. Tomatoes must be stemless when removed from the vine with stem scars less than 0.25 in. (6 mm) in diameter. Further the stem scar should not brown during processing.
6. Tomatoes for peeling should be round to oval in shape, but shape may vary for those to be juiced or crushed.
7. Fruit size should be uniform with no fruit smaller than 50 grams and none larger than 90 grams.
8. Tomato total solids content should be in excess of 5.5% and preferably upwards to 8.5%.
9. Tomato soluble solids content (Brix value) should be in excess of 4.5% and preferably to 7.5%.
10. Tomato water insoluble solids content should be in excess of 1% and increasing proportionally with total solids content.
11. Tomatoes should have a high acid (citric) content (minimum of 0.35% and up to 0.55%).
12. Tomatoes should have a low pH value (maximum of 4.4 and preferably all fruits with a pH of 4.2 or less).
13. Tomatoes should be high in Vitamin C content (in excess of 20 mg/100 g).

14. Tomatoes for canning should have skin or peel that removes easily and completely without stripping. Also, they should remain firm and whole (depending on style) after processing.
15. Tomatoes for juice production should have a thick consistency (GOSUC value of 50 or more) after manufacture and the juice should not separate while in the can or jar during shelf life.
16. All tomatoes for processing should have a bright red glossy color after processing, regardless of the processed product.
17. All tomatoes have typical tomato flavor before and after processing with no bitterness or stringent flavor.

Buying on Grade

Buying under U.S. Grade, wherein the tomatoes are graded as they come to the factory, according to set standards is widely used. The official graders are Government or State Inspectors and are paid by the canners. This system of buying the crop is already generalized, and, where properly and rigidly enforced, is more profitable for both grower and canner. The grower receives a reward in better prices for good crops and the canner saves in cost of sorting and grading and in an increased amount of quality goods.

In the U.S. the exception to the rule is the state of California, where there is a third party grading system administered by the State and all tomatoes for processing must pass the minimum state grade.

From the time the fruit is harvested to the time it reaches the washing machine, every effort must be made to avoid bruising, to keep the fruit dry and the temperature low to maintain raw material quality. The time from the field to the factory should be held to a minimum.

Harvesting

Tomato varieties have been developed that allow mechanical harvesting of whole fields at one time. Depending on the variety and environmental conditions, approximately 80 to 90 percent of the tomatoes in a field mature simultaneously. A small percentage of the crop is picked while still too green for canning, and another small fraction is lost in the field and plowed under because it is over mature. In the U.S. practically all the tomatoes for processing are now mechanically harvested.

Inspection

The first factory operation should be that of inspection. A sample is taken at random from a load and turned upon a table to be graded based on color and to determine the percentage of defective fruit present.

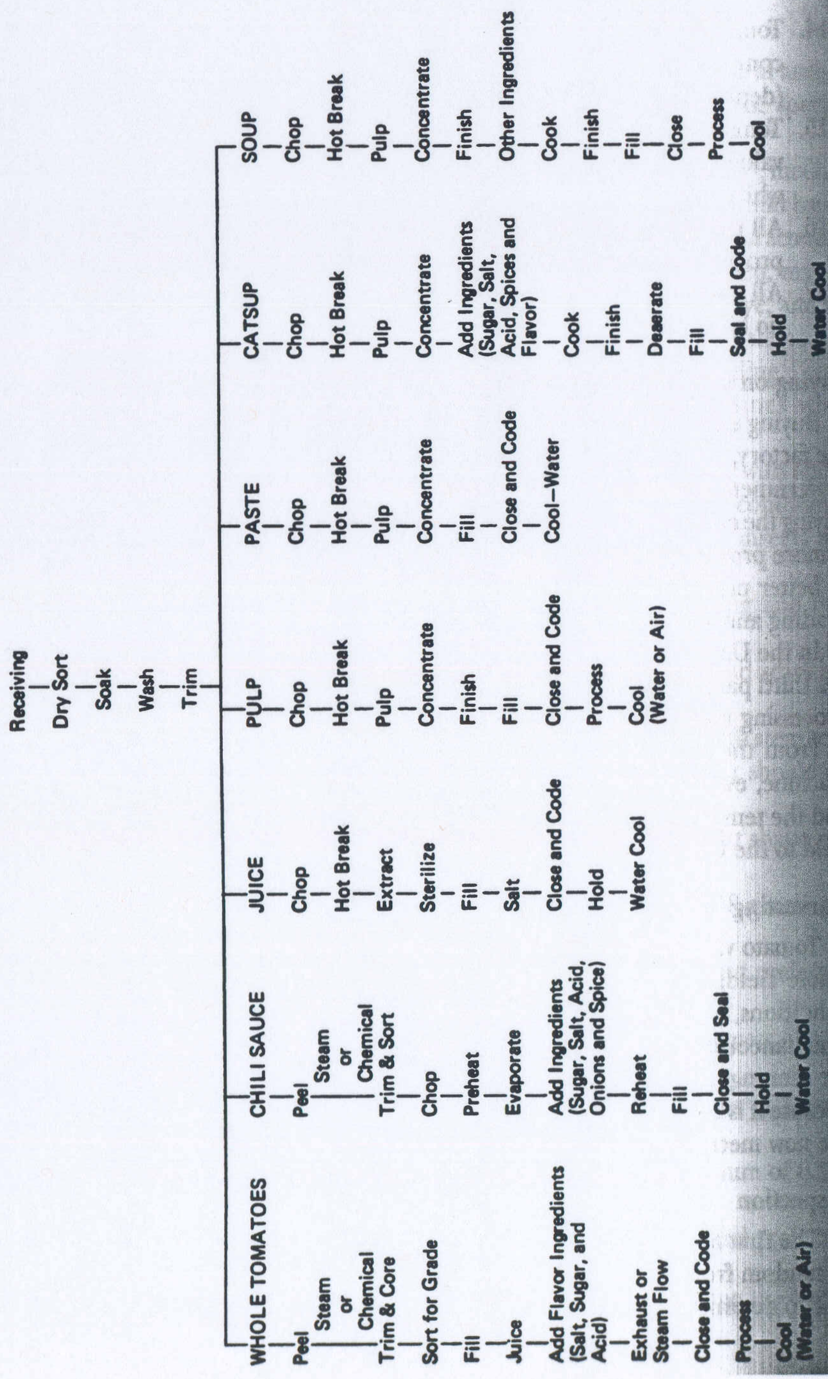

FIGURE 12.1 – Processing of Tomatoes (Courtesy Gould, 1992)

Dry Sorting

Tomatoes are dumped from hampers, lug boxes or bulk trailers into a water canal that conveys them to a dry sorting inspection belt to remove the fruit that is grossly contaminated (material other than tomatoes) or defective (green, decomposed or otherwise unfit).

Washing

Thorough washing is essential whether the tomatoes are intended for canning or for a pulp product. There are many devices to accomplish this end, but a combination which gives three to five minutes of soaking at 130°F (54°C) with subsequent spraying that reaches every part of the surface is recommended. Whether soaking is needed will depend largely upon the kind of soil in which the tomatoes were grown and the amount of rain. Tomatoes from a rather sandy loam and picked in dry weather will have very little if any earth attached that cannot be removed by sprays alone. Tomatoes harvested from clay soils or after rains are likely to have earth on the surface which becomes adherent in a hot sun. To meet all emergencies, use of a soaking tank as a preliminary step is advisable. It is desirable to add sodium hypochlorite to the soaking water to control thermophilic buildup (residual chlorine concentration of 6–8 ppm). Some means of agitating the tomatoes in the water, such as paddles, propeller wheel, or compressed air, aids in loosening dry masses or grit. Mechanically harvested tomatoes usually have more adhering soil than hand-picked fruit and they should always be soaked. Soaking in a slightly alkaline solution (pH 10–12) has been recommended when fruit fly contamination may be a problem.

Following the soak, the tomatoes may be carried up a gentle incline by flights and subjected to sprays, carried on a perforated belt and sprayed from above and below, or passed through a rotating drum and sprayed. The first two methods are most frequently used for tomatoes to be peeled and the last for pulp products, since it is more vigorous than desired for the canned fruit. The efficiency will depend upon the pressure of the water and whether it reaches all parts of the fruit. Sprays without pressure have little cleaning effect even though the volume may be large. Impact, coverage, particle size and volume of water used depend on the pressure applied. Pressure of 130 psi (896 kPa) is ideal for reducing drosophila eggs and for having the least increase in tomato waste. The second factor is the volume of tomatoes passing through the machine. The most efficient machine made can be so overloaded it becomes ineffective.

On a belt conveyor with tomatoes three, four or five deep, sprays of water wet only some and make the skins bright so that to the novice they appear washed. The rotary washer, especially if made with corrugations, is especially efficient for pulp. The tomatoes are rolled against each other thus assisted by friction in getting rid of dirt and surface decay.

Sorting and Trimming

Tomatoes are sorted and trimmed to remove off-color and defective fruit or fruit parts (rotten areas, mold portions, insect damage or sun-scald). Unevenly ripened and overripe fruit should be used only for pulping. For efficiency in sorting, tomatoes are turned on roller conveyors and sorters separate tomatoes which should be completely discarded from those capable of being trimmed.

Scalding

The scalding operation is not performed in most large commercial tomato canning plants today, but it may be a necessary step in a small scale operation.

The object of the scalder is to heat the skin to the scalding point quickly enough so the fruit is not heated. Steam is usually more efficient than water requiring about thirty seconds if adequate steam pressure is available. Spraying with cold water should immediately follow in order to loosen the skin and prevent overheating the fruit.

Coring

Standards of Identity state that stem scars greater than 0.25 in (6 mm) in diameter require coring the tomato. Many new varieties do not need to be cored and therefore savings in drained weight and wholeness are realized. Either hand or water-powered machine coring is possible, but machine coring is generally less expensive and less wasteful.

Peeling

Two main tomato-peeling methods are used today; steam and lye peeling. Choice of method is dictated by equipment cost, fruit volume and end product quality desired. Hot water peeling may still be used for some applications.

Steam Peeling: Tomatoes are scalded in live steam long enough to loosen skins but not so long that the pulp and flesh become soft or that the tomatoes are thoroughly heated (Cruess, 1958).

Scalding is accomplished by conveying tomatoes through a live steam chamber at 208–212°F (98–100°C) for 30 to 60 seconds or longer, depending on variety, fruit size and stage of maturity. Pressurized continuous chambers which allow for superheating steam up to 300°F (149°C) are also available and result in higher drained weights and good fruit quality. As tomatoes emerge from the scalder, they are subjected to sprays of cold water or a dry vacuum to crack the skin.

Tomato skins must be completely loosened or additional labor will be required in hand peeling. This will increase labor cost, add to production time, give an undesirable appearance and generally leave some peel on the finished product. On the other hand, over-scalding will soften tomatoes and result in excessive product losses and poor quality.

Lye Peeling: Caustic soda (sodium hydroxide, NaOH) attacks the cuticular tissue of the tomato and causes its dissolution. Tomatoes are typically dipped or sprayed with lye at 190–210°F (88–99°C) for 20 to 30 seconds, drained, held for 45 to 60 seconds to allow reaction time, and then washed thoroughly with cold water (citric acid may be added) to remove excess lye and disintegrated peel. A second rinse with up to 10% citric acid solution may be applied to control lye carryover on tomatoes. Caustic soda concentration used ranges from 16–20% depending on temperature and wetting agent used. Wetting agents allow for uniform peeling either in less time or with lower lye concentrations required. Sodium 2-ethylhexylsulfate and sodium mono- and dimethylnaphthalene sulfonates are common anionic surfactants approved by FDA for use as wetting agents (Gould, 1992).

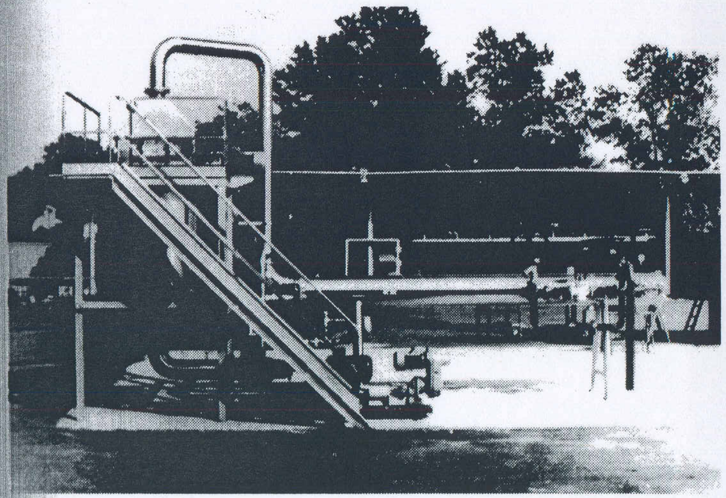

FIGURE 12.2 – Tomato Peeler (left), Tomato Peel Remover (right) (Courtesy FMC Corporation)

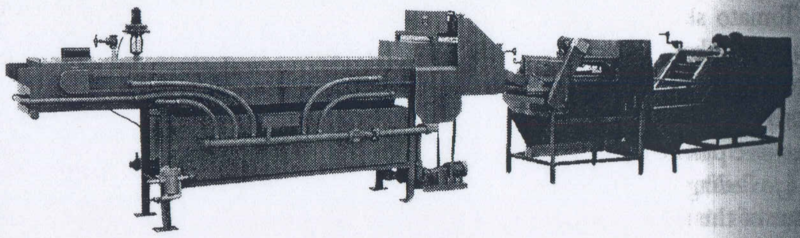

FIGURE 12.3 – Caustic Peeler (Courtesy Leader/Fox)

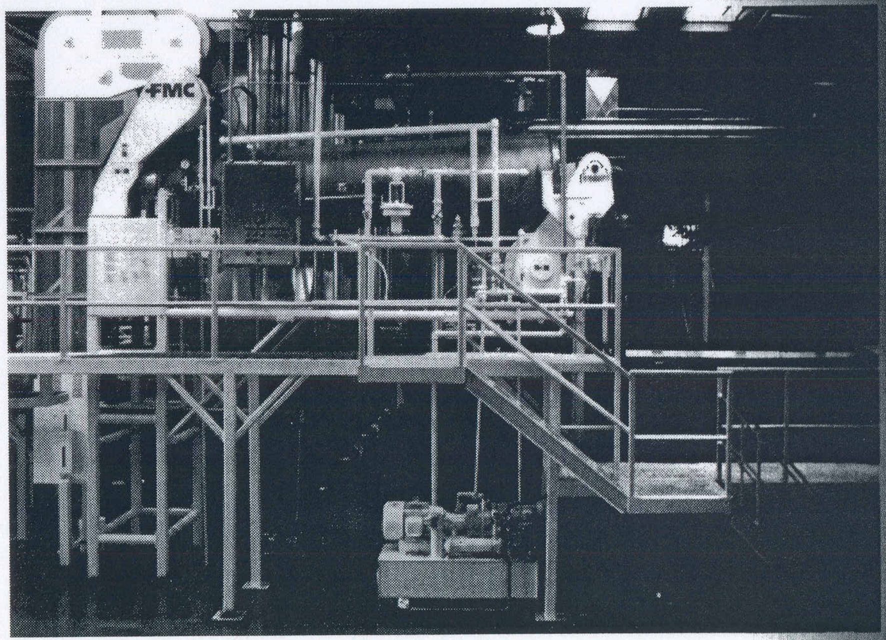

FIGURE 12.4 – Wet Vacuum System for Peeling Tomatoes, Actual Layout of Equipment (Courtesy FMC Corporation)

WHOLE PEELED TOMATOES

Filling

Cans made of 75-25 differential electrolytic tinplate with enameled bodies and ends, high tin fillet (HTF) side seam, and inside side seam stripe of enamel are used for canning whole tomatoes.

Filling of tomatoes is usually done mechanically. First, one or two tablets containing salt (NaCl), calcium chloride, an acid, a sweetener, and other optional

ingredients permitted under the standard of identity, are mechanically deposited into the can. (See section on Salt and Salt Tablets Deposition in the chapter 11 "Ingredients," Book II). Sodium chloride-calcium chloride solutions may also be dissolved into tomato juice and added to cans as a concentrate. A small amount of a permitted acid is included, if necessary, to lower product pH. Tomato juice is added by means of a volumetric filler, followed by the peeled whole tomatoes.

Fill of container, drained weight, and equilibrium pH must be carefully controlled. The presence of any substances other than tomato must be declared on the label. The amount of salt (NaCl) added is usually about 0.5 percent.

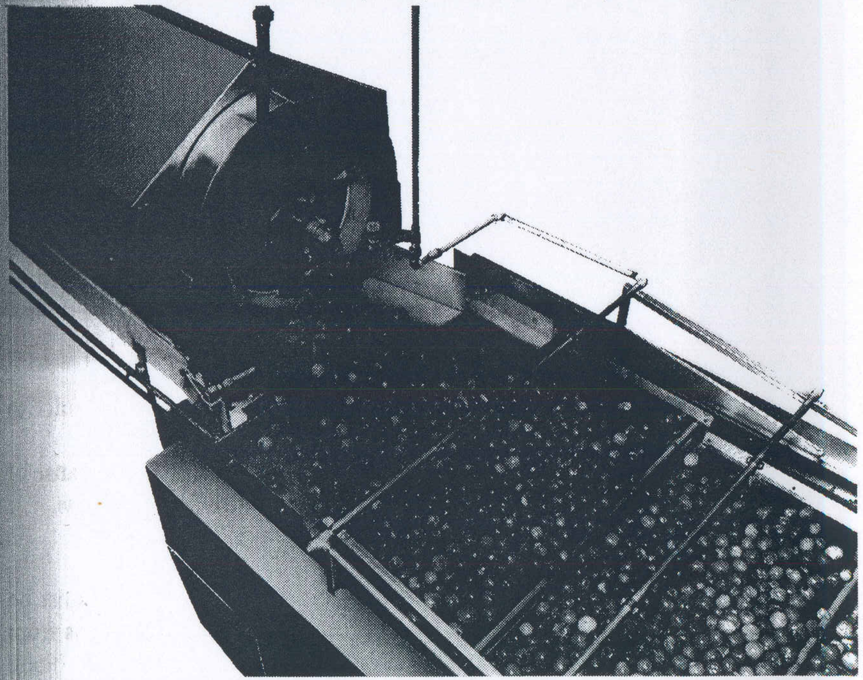

FIGURE 12.5 – The Magnuson STEPEEL unit receives tomatoes from the MAGNUSCRUBBER Model HC Dry Peeler, and efficiently removes skin tags and loose peel. (Courtesy Magnuson/CCM)

Use of Firming Agents

Tomatoes soften during cooking and lose textural integrity in the can. The addition of a small amount of a firming agent keeps the tomatoes firmer and tends to minimize the breakdown. The FDA has approved use of the following salts as firming agents: purified calcium chloride, calcium sulfate, calcium citrate, mono-calcium phosphate or any two or more of these in concentrations not to exceed 0.045% except for diced, wedged or sliced tomatoes and not to exceed 0.08% calcium by weight in the finished canned tomatoes (21 CFR 155.190, 1994). The addition of a firming agent must be declared in the label. Calcium chloride is usually added with the salt in the form of special tablets, or as a solution of sodium chloride-calcium chloride dissolved in tomato juice.

Acidification

As discussed previously, some of the new varieties developed for mechanical harvesting have a higher pH value. An acid should be added to those varieties in sufficient concentration to bring the pH of canned tomatoes during sterilization to a value of 4.3 or lower. Control of flat-sour spoilage in canned tomatoes is more difficult if the pH increases above 4.6. The FDA Standards of Identity for canned tomatoes allow the use of any edible organic acid for the purpose of acidification, within certain other provisions of the Standards. Edible organic acids include citric, malic and fumaric, but citric is most common.

Citric acid may be added by five methods:

1. Direct addition of granular anhydrous citric acid by a dispenser or salt tablet. This is the most commonly used method.
2. Addition of citric acid to tomato juice as an optional packing medium.
3. Addition of a dry mixture of citric acid and salt.
4. Dipping tomatoes in a citric acid bath following peeling.
5. Addition of a measured quantity of a solution of acid in tomato juice to each empty can prior to packing.

The acidification system must insure that every can is acidified because of the danger of potential germination and growth of *Clostridiun botulinum.*

Exhausting

As tomatoes are generally filled into cans cold, the filled cans must be exhausted so that sufficient vacuum may be obtained to keep the cans from spoiling during storage. Solid-packed tomatoes heat very slowly (Cruess, 1958). Therefore, tomatoes should be thoroughly exhausted to increase the initial can temperature. The following should be minimum times of exhaust:

No. 2 or No. 303 cans	3 minutes
No. $2^1/_2$ cans	4 minutes
No. 3 cans	4 minutes
No. 10 cans	10 minutes

The temperature of the exhaust box should be 190–200°F (88–93°C). Steam exhaust is generally used although there is no reason why a water exhaust box could not be used. There are several types of exhaust boxes on the market

which are satisfactory. Some canners use home made types, most of whicl consist of a long narrow box through which runs a conveyor and a perforatec steam pipe. As a rough test of the efficiency of the exhaust, a can of cold wate passed through it should be raised to a temperature of 200°F (93°C). In eithe case, the center of the can should reach 130°F (54°C).

A satisfactory vacuum can also be obtained by a steam-flow closing machin if the head space is carefully controlled to $^5/_{16}$ in. (8 mm) for small cans an $^6/_{16}$ in. (9.5 mm) for No. 10 cans. In addition, mechanical vacuum closin machines may be used.

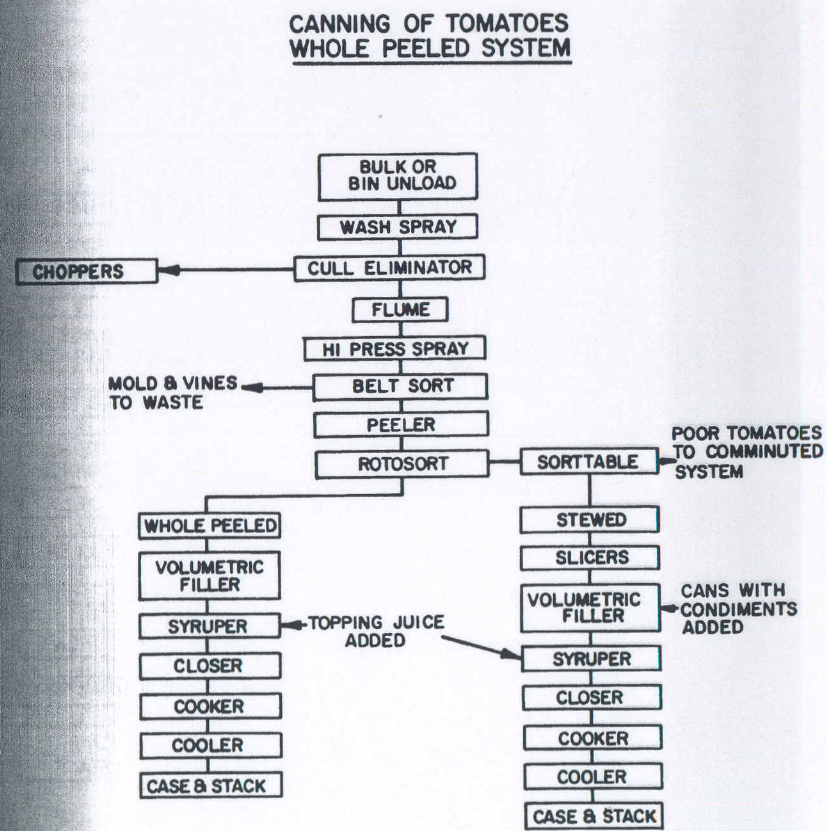

FIGURE 12.6 – Canning of Tomatoes, Whole Peeled System

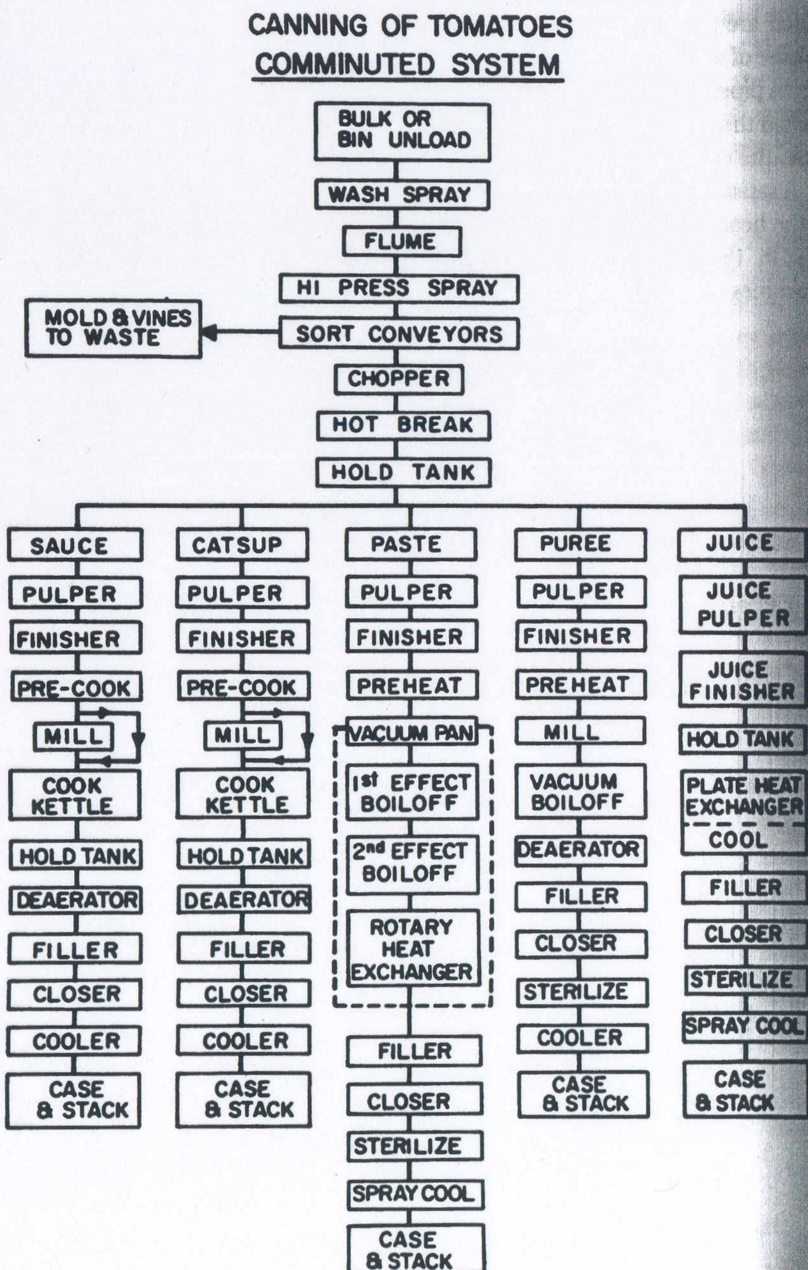

FIGURE 12.7 – Canning of Tomatoes, Comminuted System

Process Time and Temperature

Process times and temperatures for canned whole peeled tomatoes depend to a large degree on the type of equipment used. Agitating continuous cookers, which operate at 212°F (100°C) are more commonly used today than retorts or open still cookers. Recommended process times are presented in Table 12.1 below.

TABLE 12.1–Recommended Processing Times in Minutes for Canned Tomatoes by Can Size (Gould, 1992)

Can Size	Still Retort @ 212°F/100°C Water Cool	Still Retort @ 212°F/100°C Air Cool	Agitating Cooker @ 212°F/100°C Water Cool	Agitating Cooker @ 212°F/100°C Air Cool
303x406	45	35	14	9
307x409	45	35	14	9
401x411	55	45	18	13
603x700	100	80	25	20

Five to ten minutes should be added to the above times for tomatoes closed cold using steam flow or mechanical vacuum can closing machines for still retort processing. The above processes may also be used where steam at 1 psi (7 kPa) pressure, corresponding to a temperature of about 215°F (102°C), is used as the sterilizing medium.

It is advisable to check the can center temperatures of processed cans in order to ascertain the efficiency of a process. Several devices for determining accurately can center temperatures are available. As a general rule, it is advisable to process tomatoes to minimum can center temperatures of 180°F (82°C) where air cooling is used and 190°F (88°C) where water cooling is used. The water used for cooling should be chlorinated and reasonably low in bacterial count.

Processing Mechanically Harvested Tomatoes

Three key factors have dictated changes in tomato processing plants packing mechanically harvested tomatoes:

1. Harvesters break off longer stems and leave on more stems than manual pickers.
2. New varieties are smaller, so more tomatoes are handled per inspection belt.
3. Varieties developed for mechanical harvesting usually have a higher pH value.

Varieties developed for mechanical harvesting generally have a higher finished product pH, usually in excess of 4.3, especially with mechanical lye peeling. To avoid the potential for flat sour spoilage, acidification with upwards to 0.1% citric or another permitted acid is recommended to ensure an average pH of less than 4.3. Standard calcium-acidulant-salt tablets formulated with a disintegrating agent to ensure rapid solubility and dispersion of acid are commonly employed with mechanically harvested varieties.

On the other hand is the fact that new varieties are coreless. This was an unexpected side benefit of breeding a tomato with a weak stem that would shake off the vine easily when mechanically vibrated. The coring operation has been eliminated, freeing large numbers of workers who oriented tomatoes into the coring machines, and who hand cored those missed or improperly cored in the machine.

Stem removal is another operation that is performed mechanically in automated systems. In less automated operations stem removal is sometimes performed by hand. Stem count may vary from 5% to more than 90% depending on locale, season, weather and other variables.

Minimizing Drosophila Contamination

The control of Drosophila flies should start at the source of egg deposition, i.e. the field, and continue through subsequent handling operations. In conjunction with these control measures, tomatoes should receive effective treatment in the plant to help reduce Drosophila contamination.

Following are suggested steps for handling and washing raw tomatoes in the plant.

Inspection – When a given lot or load of tomatoes has many cracked or damaged fruits, it is advantageous to have an inspection operation to remove any fruit damaged beyond use. The removal of such fruit prevents unnecessary contamination. Lots heavily infected should be rejected and not processed.

Dry Sort – The purpose of a dry sort is to remove gross contamination and unusable tomatoes which would otherwise contaminate wash waters. A wire mesh conveyor or roller belt which allows loose materials to be separated from the tomatoes helps to accomplish this step.

Pre-Wash – The purpose of a pre-wash is similar to the dry sort, that is, to remove gross contamination prior to the main wash. Although a soaking or immersion type washer with agitation followed by sprays would be preferable, a chain type conveyor may suffice if there are enough high pressure spray nozzles to do an effective job of removing field soil, etc. Unloading water flumes are also helpful. The soaking wash should contain up to 200 ppm of available chlorine and subsequent flood-washing should maintain a minimum of 5 ppm of residual chlorine. It is recommended that the water temperature in the soaking tanks be held below 80°F (27°C).

Main Wash – The tomatoes should be completely immersed, well agitated and followed by a bank of high-pressure spray nozzles. The pressure should always be at least 50 psi (345 kPa) and much higher if the tomatoes are not damaged too badly. If necessary, connect a booster pump to spray lines so that water usage elsewhere in the plant will not affect the nozzle pressure. Agitation can be accomplished by paddles or by introduction of compressed air into the soak tank.

Studies have shown that the addition of detergent or lye (caustic soda) to the soaking portion of the main wash is of significant benefit in loosening and removing Drosophila eggs and maggots. If lye is used, the following specifications should be adhered to:

The soaking or immersion portion of the main wash should (1) be of adequate size to retain the tomatoes for 1-3 minutes, (2) have steam coils so that the temperature of the water can be elevated to 140°F (60°C), (3) be well agitated. To this washing tank add and maintain 0.25 to 0.50% lye ($NaOH$), pH 12 or above. Water should not be heated unless lye is present because of a possible bacterial buildup.

Final Wash – The final wash with fresh water should include a soak, with agitation, and a high-pressure spray rinse. If lye is used in the main wash care should be used to see that it is completely removed in the final wash. The tomatoes should make at least two complete revolutions on a roller conveyor while under the sprays. Water pressure should be maintained as recommended for the main wash.

CANNED STEWED TOMATOES

This is a formulated product consisting essentially of tomatoes, tomato juice, celery, onions, peppers, salt, sugar and spices. A suggested general formula that can be altered in accordance with the canner's taste and demands of the trade is as follows:

TABLE 12.2 – Stewed Tomato Formula

	Percent by Wt.	Wt. per No. 2 Can
Tomatoes (peeled sections or small whole)	69.21	382.72 g
Tomato Juice	28.12	155.92 g
Sugar	1.17	6.48 g
Onions, dehydrated chips	0.54	3.00 g
Salt	0.54	3.00 g
Bell Peppers, dehydrated dices	0.18	1.00 g
Celery, dehydrated stalks or flakes	0.18	1.00 g
Stewed Tomato Seasoning	0.06	0.36 g

The tomatoes used for this product are prepared by the same procedures employed for whole peeled canned tomatoes. The fruit is washed, inspected, scalded, cored and peeled. Not as much care is required during peeling as the tomatoes are broken or cut into sections for this product. Generally, high standard grade tomatoes are used for this pack and some canners prefer to use extra standard grade. While it is desirable to have the tomatoes in sections or small pieces, maintenance of textural integrity is important.

Before filling tomatoes into the can, a mixture of the dehydrated vegetables and a mixture of the desired quantities of sugar, salt and seasoning are placed in the bottom of the cans. The required proportions of dehydrated vegetables should be mixed together thoroughly by stirring, as shaking these ingredients together would not be satisfactory because the lighter pieces would come to the top. A canner can prepare his own seasoning mixture, or a seasoning mixture for stewed tomatoes can be obtained from one of the spice manufacturers. Machines are available for adding accurately measured quantities of these two mixtures to the empty cans. Some type of cutter may be incorporated in the line prior to the filler bowl.

The tomato juice should be heated to 190°F (88°C) or above prior to adding to the can. As with whole peeled tomatoes, stewed tomatoes should be acidified (0.1 to 0.2% citric acid), calcium chloride added at a rate of 0.1% and processed to a center temperature of 190°F (88°C).

DICED TOMATOES

The demand for diced tomatoes as ingredients in products such as pizza sauce, spaghetti sauce and salsa has risen astronomically during the 1990s, however a Standard of Identity has yet to be defined by the FDA. The selection of appropriate variety for processing is crucial to producing dice pieces of the highest textural integrity and most intense red color.

Preparation and Peeling

Tomatoes destined for diced products are dry sorted, washed, color sorted (electronically or manually) and conveyed into the peeler. Typically steam or caustic (lye) peelers are utilized in diced tomato processing, both of which were described in the General Canning Guidelines section of this chapter. The objective of the peeling operation is to split or crack the tomato peel to a sufficient degree that the peel will be subsequently removed when the tomato passes over the mechanical peelers, typically a rubber disc roller followed by a pinch roller bed. Subjecting the tomato to too much heat may result in the removal of excessive amounts of tomato flesh and a reduction in yield. Optimization of the peeling operation to achieve adequate peel loosening without excessive yield loss is a challenge, and will depend to a large part on tomato variety, maturity, and fruit size.

Steam peeling conditions typically utilize temperatures ranging from 212–250°F (100–121°C), depending on the availability of pressure to raise steam temperatures above 212°F (100°C). A well designed steam peeler may be able to achieve internal temperatures of 250–300°F (121–149°C) through use of 15-125 psi (103–861 kPa), respectively. In general, more efficient peeling is achieved with less yield loss through use of high temperature, short time steam peeling operations. Times required to accomplish an adequate crack in the tomato peel range from 15–120 seconds, again depending on the variety, maturity and fruit size. At the steam peeler outlet, tomatoes are often exposed to a vacuum or cold water spray to assist in peel removal.

Lye (caustic) peeling typically yields cleaner fruit with less yield loss, but manufacturers are faced with the need to dispose of waste lye. The active agent in lye peeling is sodium hydroxide, NaOH, or caustic soda, which dissolves cuticular wax and peel material. Tomatoes are either immersed in a hot lye bath or sprayed with lye for a defined amount of time. Sodium hydroxide concentration usually ranges between 16–20%, depending on the temperature and wetting agent added. FDA regulations (21 CFR 121.0191) require that the use of wetting agents be followed by rinsing with potable water to remove chemical residues. The lye solution utilized is typically between 190–210°F (88-99°C) and exposure time ranges between 20-30 seconds. Fruit is often allowed a 45-60 second reaction time and then cold water is sprayed to remove the digested peel (Gould, 1992).

Dicing, Sorting and Calcification

Following peeling and passage over a mechanical peel removal bed, peeled tomatoes are sorted to remove flags (small pieces of adhering peel), off-color and moldy fruit. Typical dice sizes produced include the following: 1 x 1 x 1 inch (25 x 25 x 25 mm), 1 x $^3/_4$ x $^3/_4$ inch (25 x 19 x 19 mm), $^1/_2$ x $^3/_8$ x $^3/_8$ inch (13 x 9.5 x 9.5 mm), $^1/_2$ x $^1/_2$ x $^1/_2$ inch (13 x 13 x 13 mm), $^5/_8$ x $^5/_8$ x $^5/_8$ inch (16 x 16 x 16 mm) and others. Choice of dice size will depend on the characteristics of the final product to which the dice ingredients are added, but will be limited by the need to insure adequate heat penetration into the dice pieces during thermal processing.

Following dicing, the product is often passed over a shaker belt to remove slivers of tomato pieces, juice, etc., and then sorted again for stems, off-color and moldy fruit. Dice pieces are commonly passed through calcium chloride baths or sprays to improve their textural integrity. Plant tissues consist of a multitude of cells which are bounded by pectin-containing cell walls, and the pectin-rich middle lamella which serves to "cement" cells together. Divalent calcium ions bind the free carboxyl groups of adjacent pectin polymers, creating a more stable three dimensional network and imparting additional firmness to plant tissues. The addition of calcium salts to tomatoes causes the formation of a calcium pectate gel which supports the tissues and minimizes tomato softening.

The FDA has approved the use of the following calcium salts as firming agents: purified calcium chloride, calcium sulfate, calcium citrate, mono-calcium phosphate, or any two or more of these in combinations not to exceed 0.08% calcium by weight in the finished product. Calcium bath concentration, dice temperature and residence time in the bath all influence the final residual concentration of calcium in the diced pieces. Calcium bath concentrations may range from 800–1200 ppm and residence times may be as short as 30 seconds or as long as 3.5 minutes.

Cooking and Cooling

A number of different cooking methods have been employed for diced tomatoes, depending on availability of equipment, desired end product and dice size. In some operations, dice pieces are essentially blanched (212°F or 100°C) on a wire mesh belt for up to five minutes. Other tomato processors employ hot water or hot topping juice or tomato puree as a cooking medium for dice pieces which are augered through. In this instance, the cooking medium temperature is close to boiling and the residence time is considerably shorter, usually less than two minutes. Finally, other processors may employ a hot or cold fill method into cans which are further processed. In the case of bulk aseptic dice processing, where dice are filled hot into 55-gallon drums or bag-in-box containers, dice pieces are usually cooked by blanching or augering through a water or topping juice cooking medium.

Following filling of bulk containers it is imperative to cool them as rapidly as possible. Many operations use systems in which drums are rotated under sprays of room temperature or cold water. In the case of retail size cans, cans are typically conveyed through a water bath until their internal temperature has been reduced to at least 100°F (38°C).

TOMATO PUREE (PULP)

Tomato pulp or puree is covered by USDA Standards for Grades and by FDA Standard of Identity. It must contain at least 8.00% tomato solids, but less than 24.0%, of salt-free tomato solids.

General Operations

There are two general types of tomato pulp, one made from whole tomatoes and the other made from tomato by-products such as the skins and cores from canning tomatoes or the partially extracted tomatoes from the manufacture of tomato juice.

Whole tomatoes are washed, sorted and trimmed to remove all visible defects. This is a very important step in making pulp that will meet official requirements. The tomatoes either pass directly to a cyclone for "cold break" process or to a chopper or crusher and then a preheater followed by cycloning for the "hot break" process. The hot break process inactivates enzymes and prevents destruction of the naturally occurring pectin, therefore resulting in a thicker pulp. Hot break temperatures are typically above 170°F (77°C), while cold break temperatures are below 150°F (66°C). The cyclone juice from either process goes to the pulp tank for boiling down to the desired concentration.

Tomato by-products are put through a pulper either before or after being heated.

The most rapid and accurate method for determining concentration is using a refractometer. A drop of the juice is quickly read in the refractometer and the concentration is determined. The instrument is easy to operate and saves much time in the cook room.

Evaporation is carried on in tanks with coils or in vacuum pans. Tanks may be made of stainless steel or of monel metal, should be easily cleaned, and coils of the same metal are recommended. Aluminum is not recommended because acid can severely pit the tanks and oxidation may occur.

Evaporation efficiency depends upon a good steam supply under pressure (100 psi/700 kPa or over) and steam traps. Coils operating under low pressure burn and cause solids to stick on the surface, resulting in little, if any, evaporation. This difficulty can be overcome to a certain extent by forced circulation with a propeller stirring device. A hot coil causes rapid circulation which prevents burning or sticking. The foam on pulp is best broken by a blast of air from a small blower. A vacuum kettle works quickly, but, as the pulp needs a high temperature for sterilization, there is not a great deal of gain.

The steam should be turned on as soon as the coils are covered with pulp. To secure the best color and flavor, evaporation should be as rapid as possible. The evaporation time of a batch should preferably not be longer than thirty minutes. With proper operation of the steam traps on the coils and proper boiler pressure, a batch of 600 gal. (2,271 L) can be concentrated to 1.035 specific gravity in 25–30 minutes. A steam pressure of 100 psi (689 kPa) can be carried by the average steam coil. To ensure rapid evaporation, it is essential that the coils be kept thoroughly clean. Any pulp which bakes onto the coils should be removed, otherwise it will decrease heat transfer and may also peel off leaving black specks in the pulp. The specific gravity of the juice as it comes from the cyclone is ordinarily around 1.020, but varies with the season and the locality. One thousand gal. (3,785 L) of 1.020 cyclone juice will give

574 gal. (2,173 L) of 1.035 pulp, 501 gal. (1896 L) of 1.040 pulp, or 444 gal. (1,680 L) of 1.045 pulp, and 398 gal. (1,506 L) of 1.050 pulp.

Cyclone juice is usually pumped to a storage tank and withdrawn from this to the evaporating kettles as needed. If the cyclone juice is left in the storage tank undisturbed for any length of time, the insoluble fiber will rise to the top and liquid withdrawn from the bottom will be watery, resulting in batches of pulp which vary in consistency. It is suggested that the storage tank be equipped with a steam coil so that the contents may be kept hot and mixed at all times. Some manufacturers also install a mechanical stirrer to insure thorough mixing.

An older method consisted of evaporating to one-half the volume of the original juice, or until it reached a certain consistency as determined from its appearance in breaking from a spoon or the dipper. This method has been abandoned as being unreliable and exceedingly variable as a basis upon which to buy or sell. This method is used only by those who pack pulp for their own use or the very few who purchase upon sample. A slight difference in specific gravity may mean a considerable volume in raw juice for concentration. The average specific gravity of pulp evaporated to one-half its volume is about 1.035 and this has been accepted as the standard for pulp. Pulp is now made to gravities of 1.040, 1.045 and 1.050 and even higher in order to save cans and freight in shipment, but the price should be scaled on the basis of the tomato solids content.

After the pulp has been evaporated, it is run through a finishing machine to remove any rough particles or fiber which were driven through by the pulper. It is then filled into cans at temperatures of 190°F (88°C) or higher.

Some manufacturers finish the pulp immediately after the cyclone so that it may be drained directly from the kettle to the filler or into the receiving tank, then into cans as close as possible to 190°F (88°C). Finishing before cooking takes out more tissue but does not give as good an appealing product as when finishing is carried out after cooking. Pulp filled at 190°F (88°C) and not cooled generally keeps, but there is always an element of uncertainty. Pulp canned hot, given a thirty minute bath, and then cooled is more certain of keeping and will have a brighter, cleaner appearance.

Where the product is not processed in the cans, the filled containers, after leaving the closing machine, should be passed through a warm water spray to remove any pulp on the outside. Unless care is used in cooling loss in color and flavor and even stack burning may result.

Determination of Specific Gravity

There are several methods of determining specific gravity, but all have some objection when applied to hot products where speed is required. Hydrometers are not adapted for obtaining the specific gravity of liquids containing suspended solids and there is not time to filter samples, test the filtrate, and compare the results with tables of equivalents. Taking samples, centrifuging them and weighing, correcting for temperature, etc., is not a fast enough method. The specially constructed volumetric flask and scale is quickly manipulated, and though only approximate, is useful in connection with the measuring stick. The volume of the standard batch should be calibrated at the boiling temperature and again at the finishing point. The measuring stick will indicate both, so that the work need only be slackened, but not interrupted.

Details of the work on determination of the specific gravity of pulp have been published by National Food Processors Association (1992), but a very brief compilation from one set of figures will serve to show the need for having a standard and a common basis for sales.

In other words, each one-thousandths increase in specific gravity of finished pulp, requires an increase of one-fourth of one percent in solids and is equivalent to 31 gal. (117 L) of pulp of 1.035 gravity for each thousand produced. One thousand gal. (3785 L) of pulp at 1.055 is equivalent to 1,582 gal. (5,988 L) of pulp at 1.035.

Equipment

Because tomato juice and tomato pulp are high in acid and therefore corrosive, pipes and other equipment should be made of some non-corrosive material. Copper steam coils are generally used and are satisfactory. They should be well cleaned at the beginning of the season to remove the copper oxide coating from the surfaces.

Tin-lined, copper-jacketed kettles or enamel lined tanks are used for evaporating the pulp, as are tanks of stainless steel.

Galvanized iron pipes are not satisfactory for conveying pulp or cycloned juice. Tin lined, nickel, block tin, monel metal, and enamel lined pipes are satisfactory. Enamel lined pipes tend to corrode and chip at the joints and should be taken down and cleaned at the end of the season and put in storage until the next season. High chromium steel alloy pipes are also available. This material is non-corrosive and is very satisfactory for conveying tomato products.

TABLE 12.3 – Number of Gallons (Liters) of Pulp at a Specific Gravity of 1.035, Equivalent to 1,000 (3,785 L) Gallons of Pulp of Higher Specific Gravity

Sp. Gr. @ 68°F	% Solids	Equiv. Gal. @ Sp. Gr. 1.035	Sp. Gr. @ 68°F	% Solids	Equiv. Gal. @ Sp. Gr. 1.035
1.035	8.37	1000	1.056	13.57	1651
1.036	8.62	1031	1.057	13.85	1682
1.037	8.86	1061	1.058	14.10	1713
1.038	9.10	1091	1.059	14.35	1744
1.039	9.35	1122	1.060	14.62	1775
1.040	9.60	1153	1.061	14.87	1806
1.041	9.85	1184	1.062	15.12	1837
1.042	10.10	1215	1.063	15.37	1868
1.043	10.35	1246	1.064	15.62	1899
1.044	10.60	1277	1.065	15.87	1930
1.045	10.84	1308	1.066	16.12	1961
1.046	11.08	1338	1.067	16.37	1992
1.047	11.33	1369	1.068	16.62	2023
1.048	11.57	1400	1.069	16.87	2054
1.049	11.82	1432	1.070	17.12	2085
1.050	12.07	1464	1.071	17.37	2116
1.051	12.32	1495	1.072	17.62	2147
1.052	12.57	1526	1.073	17.87	2178
1.053	12.81	1557	1.074	18.12	2209
1.054	13.05	1588	1.075	18.37	2240
1.055	13.30	1620			

EXPLANATION OF THE SOLIDS REQUIREMENTS SPECIFIED IN THE REVISED STANDARDS FOR TOMATO PUREE AND PASTE

In January 1970 a revision of the standards of identity for tomato puree and paste went into effect specifying a new method for reporting solids content. The older standards specified that solids be reported as "salt-free" solids based upon determination of total solids by the official vacuum drying method and subtracting from this the total salt content of the sample including natural as well as added salt. In place of a vacuum oven, solids were usually determined by means of a refractometer and conversion tables used to convert the refractometer readings to salt-free solids by vacuum oven drying.

In the 1970 standards, solids content is reported as "natural soluble tomato solids" based upon the readings obtained on the sugar scale of a refractometer at 20°C. No correction is made for the natural salt content of the product if no salt has been added.

Since the old standard was based upon total solids whereas the new standard is based upon soluble solids, the values obtained for solids according to the

new standards are always lower than those specified in the old standards. This necessitated a change in the solids limits specified in the standards and may require a change in the solids specifications for the purchase of puree and paste products. It is necessary to know, therefore, the relationship between the values specified in the old and the new standards. To simplify this conversion, the National Food Processors Association prepared a new set of tables giving values for the "natural soluble tomato solids" as specified in the new standard and the "salt-free" solids specified in the old standard. These tables present the data obtainable from the NFPA Tomato Product Tables, February 1966, in a more convenient form and present a column showing "salt-free" solids that was not given in the former tables. The calculation of salt-free solids is based upon the assumption (adopted in the new standard) that 1.6% of the soluble solids of tomatoes as determined by the refractometer is natural salt. Aside from this, no new data are presented in the new tables and the 1966 tables have not become obsolete.

Although the new standard specifies that refractometer readings be reported at 20°C, the former practice of reading the refractometer at 25°C has not been changed and the tables will make it possible to convert easily from one temperature to the other. The reason for this is that in most laboratories it is not practical to read a refractometer at 20°C and many laboratories have installed constant temperature controllers for their refractometer operating at 25°C. If readings are taken at other temperatures, a table is given to permit conversion of the sugar scale reading to 20°C. The sugar scales found on refractometer are calibrated to give sugar concentrations at 20°C and refractive index, Brix tables also employ this temperature; hence there was no choice but to use 20°C in the standard.

TABLE 12.4 – New Standard/Old Standard for Tomato Puree

	New Standard "Natural Soluble Tomato Solids" or Sugar Scale Reading at 20°C	Old Standard Salt-Free Solids
Bottom limit for puree	8.0*	8.37
Bottom limit for paste	24.0	25.0
Bottom limit for concentrated	20.0**	21.0
tomato juice	31.0	32.0
	33.9	35.0
	45.3	46.0

*Rounded off from 7.9.
**Rounded off from 19.8.

Except for the way in which values are expressed, the procedure used to determine solids using the refractometer has not changed and except for a rounding off of the figures, the new standard does not change the concentration requirements for tomato paste or puree. The previous table gives a comparison of the most common concentrations specified for tomato concentrates by both methods.

All USDA Grade Certifications now report solids according to the new standards. Purchasers of tomato paste requiring certification should express their specifications using the new values. For example, what formerly was specified as 32% paste based on salt-free solids will now become 31% based on natural soluble tomato solids. Similarly 46% paste will now become 45.3%.

All conversion tables with the exception of the temperature conversion table can be eliminated and only a single value obtained by the refractometer without reference to any other method need be reported.

TOMATO PASTE

Tomato paste is covered by USDA Standards for Grades and by FDA Standards of Identity and Quality.

The establishment of a standard of identity for this product has done much to stabilize the industry. Paste must contain at least 24.0% tomato solids on a salt-free basis. The use of artificial color is not permitted under any conditions. Only whole tomato paste may be called "Paste" without qualification. Commercially, this product nearly always contains salt and basil.

The packing of tomato paste differs from the packing of tomato pulp only in the degree to which the concentration is carried. The preliminary processing steps are the same. In concentration, the vacuum pan is preferred to the open kettle because cooking is carried out at a lower temperature. Depending on the size of the firm, concentration of tomato paste is done in single or multiple effect evaporators, with large processors using triple and quadruple effect units.

Tables exist showing the relationship between refractometer readings and the percent tomato solids in the paste. If salt has been added, a correction should be made for the percent of added salt since the standard is based on tomato solids.

Ingredients

The amount of salt needed also depends on the final concentration. Approximately 8 lbs. (3.6 kg) per 100 gal. (378 L) of finished paste is necessary. Salt should be added near the end of the evaporation, allowing sufficient time to thoroughly dissolve. Basil is commonly added as a single leaf placed on the bottom of each can or as an oil of sweet basil.

Filling and Processing

Paste should be filled into cans at a temperature of at least 194°F (90°C). This prevents the survival of microorganisms most likely to subsequently spoil the product. Can sizes of $2^1/_8$ x $2^7/_8$ in. (54x73 mm) and $2^1/_8$ x $3^1/_2$ in. (54x89 mm) are frequently used for this product.

No further heating is applied to the cans after closing, therefore hot filling and immediate seaming are imperative.

TOMATO JUICE

Canned tomato juice is covered by USDA Standards for Grades and by FDA Standard of Identity, Quality, and Fill of Container.

Tomatoes are dry sorted, washed, sorted and trimmed as described before for whole peeled tomatoes.

Extracting

Extracting may be done either hot or cold. It is generally agreed that hot extracting ("hot break") produces a better quality juice with respect to flavor, color and body. A heavier bodied, more homogeneous juice is obtained by the "hot break" method because of the heat destruction of the pectic enzymes and the more efficient extraction of pectin. These enzymes are extremely active immediately after chopping or crushing the tomato. Their activity is greatly accelerated as the temperature is increased to about 140–150°F (60–65°C). Beyond this point the activity is retarded until inactivation is reached at a temperature of about 180°F (82°C). The pectic enzymes cause a breakdown of the pectin resulting in a thin bodied product that separates readily. The temperature should be raised to at least 180°F (82°C) as quickly as possible in a matter of seconds, rather than minutes. Most packers chop (0.04–0.06 in. or 0.10–0.15 cm) or crush the fruit prior to heating while others heat the whole tomatoes in large tanks prior to extracting. Heating may be accomplished in large tanks equipped with an agitator designed to provide maximum agitation without the incorporation of air. These tanks are steam jacketed and usually contain steam coils to provide rapid heating. Steam coils should be well trapped to provide quick heating and care must be exercised to prevent "burn on" of the tomato solids. Another method of preheating consists of pumping chopped tomatoes through a tubular pipe which is encased in an outer shell into which steam is injected for rapid heating. Tomatoes are conveyed through and discharged into the extractor.

Tomatoes which are extracted cold are usually scalded prior to extracting to loosen the skins so that no tomato flesh will cling to the skins during extracting. Failure to scald before extracting reduces the yield of juice.

Tomatoes are passed directly from the scalder on an inspection belt to a chopper and then to the extractor.

The yield of cold break juice is less than that for a hot break. When tomato seeds are to be recovered for use in planting, a cold extraction is generally used.

Extraction of tomato juice may be accomplished by several different types of commercially available extractors including either the screw type or paddle type extractors. Screw type extractors press tomatoes between a screw and screen. The perforations in the screen vary but usually are about 0.02–0.03 in. (0.05–0.08 cm) in diameter. Some installations are equipped with a shaker screen ahead of the extractor where scald spots, along with stems, cores and other foreign material can be removed. When shaker screens are used, some canners employ a higher temperature hot break and a tighter setting of the extractor since stems and other material that might cause off-flavors have been removed.

Deaeration

Dissolved and occluded air incorporated during pulping and extracting may be removed by passage through an efficient deaerator. Color, flavor and vitamin C content are improved by the complete removal of air. The loss of Vitamin C is considerable in hot juice containing air but the destruction is very slight when hot juice is deaerated. For practical purposes, vacuum deaeration is usually done immediately after extraction of the juice using a 10° flash to remove the dissolved air. Deaeration is sometimes accomplished before pre-sterilization prior to filling.

Homogenization

Tomato juice is sometimes homogenized to produce a thicker bodied product and to prevent settling of the solids. The general practice is to eliminate the homogenization particularly when "hot break" juice is being packed. When homogenizers are employed they are operated between 1000 and 1500 psi (7,000–10,000 kPa) of pressure at a juice temperature of about 150°F (66°C)

Acidification

Gould, in 1992, states, "According to the new Standard of Identity of Tomato Juice, it may be acidified with any safe and suitable organic acid. The most logical organic acid to use is citric acid as it is the natural acid of the tomato. The amount of citric acid to add to the juice will vary with the makeup of the varieties being used. My recommendation is that sufficient acid should be added to balance the soluble solids content according to the data in the following table and chart to bring the product into the grade A classification for flavor. That is, if the soluble solids content is 5.5%, the acid content should be between 0.35 and 0.55%. If the soluble solids content should be as high as 6.5%, then the acid content should be between 0.40-0.65%. The best flavor in either case will be near the mid point, that is, with 5.5% soluble solids the acid should be at 0.45 and for the 6.5% soluble solids juice the acid should be at 0.50%. This is based on the fact that there are no off-flavors in the product."

Cans

Cans made of 50-25 differential electrolytic double enameled tinplate bodies and No. 25 electrolytic double enameled tinplate ends are used for tomato juice.

The empty cans should be protected from dampness and steam and kept as clean as possible during storage. The can handling methods employed should be properly designed to prevent scratching or denting, particularly at the flange of the can. Prior to filling, the cans should be spray washed with relatively large volume of water at a minimum temperature of 180°F (82°C) to remove any possible dust or other foreign material.

Pre-Sterilization

All canned tomato juice is subject to flat sour spoilage if not properly handled either during preparation or final heat treatment. To prevent flat sour spoilage of tomato juice, it is necessary that the causative organisms be destroyed by a high temperature heat treatment.

The principal organism which causes flat sour spoilage is *Bacillus thermoacidurans*, a spore-forming bacterium which is very heat-resistant when compared with most bacteria occurring in acid foods. It is necessary to heat tomato juice at temperatures higher than 212°F (100°C) to kill *Bacillus thermoacidurans* within practical time limits. Strict sanitary control over all phases of plant operating may reduce the level of contamination, but it is impossible to remove the chance of having *Bacillus thermoacidurans* contamination in the raw tomato juice. Because of this, the only safe method of processing tomato juice to prevent flat sour spoilage, provided there is no re-contamination, is to heat the juice at elevated temperatures for a sufficient period of time adequate to kill *Bacillus thermoacidurans*.

There are three types of flash sterilizers commercially available that are presently in use. They are:

1. High velocity-small tube type
2. Low velocity-large tube type
3. Plate type

In general, the pre-sterilization includes heating the juice rapidly to a temperature ranging between 250–275°F (121–135°C), holding for a period of time sufficient to obtain destruction of the flat sour organisms followed by promptly cooling to the required filling temperature. The principle is that of a heat exchanger and either steam or water is used for the heating medium. Some installations use a regenerative system thus effecting overall heat economy.

Suitable control and recording instruments are provided along with diversion valves to assure proper sterilization. Maintenance of these recording and controlling instruments is essential to assure proper operation of the sterilization equipment.

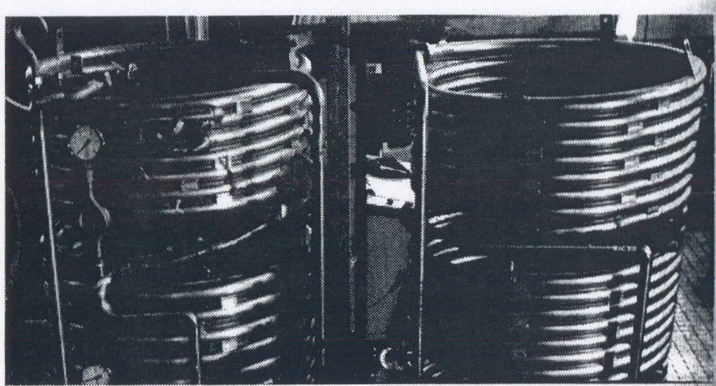

FIGURE 12.8 – Helically Coiled Multi-Tube Heat Exchanger.
Used in tomato, grape and other fruit processing industries, either as a pre-heater for pulp or as a pasteurizer for juices. (Courtesy Stork)

Filling

Standard juice fillers are used for filling tomato juice. The juice may be held prior to filling in supply tanks if maintained at a temperature of 200°F (93°C) or above. Strainers are sometimes used ahead of the filler bowl. Filling machines should be adjusted to give a maximum fill with a headspace of not more than $^{7}/_{16}$ in. (1.1 cm), or $^{10}/_{16}$ in. (1.57 cm) to top of the double seam, for No. 10 (603x700) and No. 3 cylinder (404x700). For shorter cans the measurements should not be more than $^{3}/_{16}$ in. (0.47 cm) net or $^{6}/_{16}$ in. (0.94 cm) gross.

Salt may be added to the juice at the time of pre-heating in kettle prior to filling but is generally added in the form of tablets. The tablets are automatically added to the can by a dispensing machine. The amount of salt to be added must be determined by individual needs but varies from 0.5–1.25% by weight. The average salt content of commercial tomato juice is 0.65% by weight. The quantity added to juice is usually from 4–6 lbs. (1.8–2.7 kg) per 100 gal. (378 L). Salt tablets are available in various weights so that the required amount may be conveniently added to the can with one tablet, except for No. 10 cans that may require two tablets.

Closing

Vacuum in the cans is usually obtained by filling the product at a minimum temperature of 190°F (88°C) and immediately closing the cans using an atmospheric sealer.

Filled Can Washing

It is desirable to pass the filled cans through a hot water spray washer after closure to remove any adhering product. In order to avoid cooling of the product, cold water should not be used.

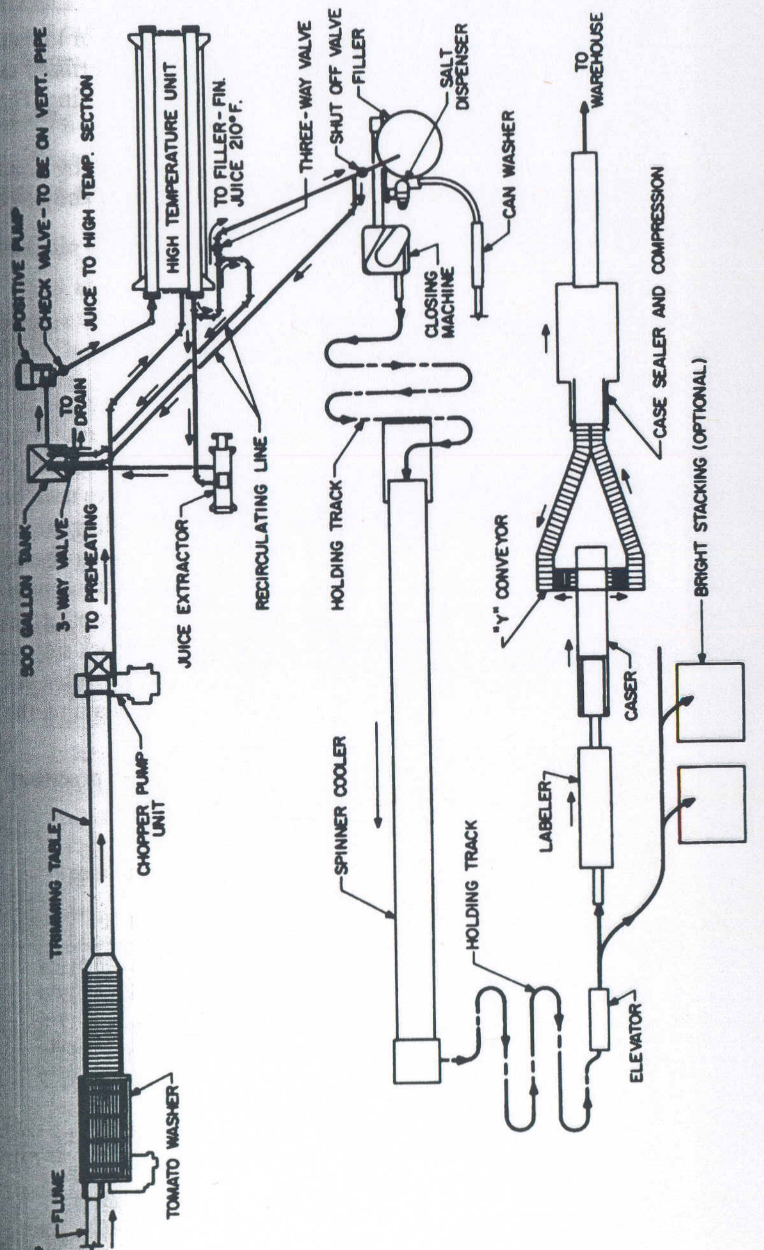

FIGURE 12.9 – Tomato Juice Line

Thermal Processing

There are several processing procedures that may be employed for tomato juice. The process used depends upon whether the juice is pre-sterilized or heat treated below 212°F (100°C) and is followed by water or air cooling. The several procedures for processing canned tomato juice are:

1) Pre-sterilized Juice-Water Cooling- The suggested minimum holding times for pre-sterilized tomato juice after closure, inverting or rolling, and prior to water cooling are as follows:

Minimum Closing Temperature	Minimum Holding Time
190°F (88°C)	3 minutes
200°F (93°C)	1 minute

These holding times are based on normal conditions and are not applicable in the case of an unusual type of bacterial contamination. Heat resistance of spoilage organisms is largely dependent on degree of bacterial contamination, pH and acidity of the product. Adequate measures must be taken in the case of 211 diameter and smaller cans to prevent cooling during the holding period. Water for washing filled cans prior to holding should be at least 180°F (82°C). Positive control of closing temperatures is essential. This may be best accomplished by some automatic temperature control and recording device in the filler bowl which would operate a can track stop or filler stop or a stop or a shut-off valve on the juice line into the filler. An auxiliary heating coil in the filler bowl would be useful in maintaining the required temperature and to raise it should it drop too low.

2) Boiling Water Process-Water Cooling- The suggested boiling water processes, followed by immediate water cooling are as follows:

TABLE 12.5 – Boiling Water Process-Water Cooling for Tomato Juice

300 Diameter or Less	404x700 to 502x510
Initial Temp. 170°F–35 min. @ 212°F	Initial Temp. 170°F–60 min. @ 212°F
Initial Temp. 180°F–30 min. @ 212°F	Initial Temp. 180°F–45 min. @ 212°F
Initial Temp. 190°F–20 min. @ 212°F	Initial Temp. 190°F–30 min. @ 212°F
Initial Temp. 195°F–15 min. @ 212°F	Initial Temp. 195°F–15 min. @ 212°F
Initial Temp. 200°F–10 min. @ 212°F	Initial Temp. 200°F–10 min. @ 212°F
303x406 to 401x411	**603x700 to 603x812**
Initial Temp. 170°F–40 min. @ 212°F	Initial Temp. 170°F–90 min. @ 212°F
Initial Temp. 180°F–35 min. @ 212°F	Initial Temp. 180°F–70 min. @ 212°F
Initial Temp. 190°F–25 min. @ 212°F	Initial Temp. 190°F–35 min. @ 212°F
Initial Temp. 195°F–15 min. @ 212°F	Initial Temp. 195°F–15 min. @ 212°F
Initial Temp. 200°F–10 min. @ 212°F	Initial Temp. 200°F–10 min. @ 212°F

3) Hot Fill-Hold-No Process Cool. This procedure is not recommended for any can size although it has been used. There is danger of spoilage caused by growth of thermophilic bacteria.

Cooling

Immediately after processing, the cans should be water cooled until the average temperature of the contents reaches 95–105°F (35–41°C).

Metallic Contamination

Any equipment containing copper, brass or iron should be eliminated because the presence of even very small amounts of iron or copper affect the final flavor of canned tomato juice. Excessive copper contamination will produce a black discoloration in tomato juice. These metals also reduce the shelf life of the product and cause considerable loss of vitamin C.

RETENTION OF VITAMIN C IN TOMATO JUICE

Tomato juice is a good source of vitamin C (ascorbic acid) provided the necessary precautions are taken in its manufacture. The following is a brief outline of the principal factors responsible for destruction of vitamin C, together with suggestions for obtaining the maximum retention of this vitamin in tomato juice.

1. Excessive incorporation of air in tomato juice is probably the most frequent cause of poor retention of vitamin C. Factors such as cyclones or finishers operated below full capacity, centrifugal pumps which suck in air, pipes discharging openly into the top of tanks, and mixers which beat air into the juice all may be responsible for the incorporation of excessive amounts of air in tomato juice. Extending or relocating pipes to deliver juice near the bottom of the tank, below the surface of the contents, may effect considerable improvement in vitamin retention.
2. Holding tomato juice containing air at high temperatures for more than a few minutes is particularly serious in causing destruction of vitamin C. If such juice must be held in storage tanks, much less destruction will occur if the juice is held at a low temperature (less than 80–90°F) (27–32°C) and then brought quickly to filling or sterilizing temperature and canned without delay. In the complete absence of air very little destruction of vitamin C will occur even at high temperatures. Efficient deaeration is highly recommended as a means of preserving the maximum amount of vitamin C in tomato juice. Cans should be well filled, since excessive headspace will lead to entrapment of air.

3. Contamination of juice with certain metals. Small amounts of certain metals, particularly copper, from equipment with which the juice comes in contact may cause serious destruction of vitamin C, especially if the juice contains air and held at a high temperature. Copper may be dissolved into the juice from copper or brass equipment, particularly after such equipment has been idle for even a short period of time. In such cases a thin film of copper oxide forms over the surface of the metal, and this film is readily dissolved by the juice. Cleaning the equipment before each production period by a method recommended to control discoloration of canned foods from copper should assist in preserving ascorbic acid. For maximum retention of vitamin C, the amount of copper or brass equipment in contact with the juice should be kept to a minimum, and the time of contact of juice with such equipment should be as brief as possible.

Proper attention to the above factors should aid materially toward securing excellent retention of the vitamin C present in the raw tomatoes.

TOMATO KETCHUP (CATSUP)

Tomato ketchup or catsup is covered by USDA Standards for Grades and by FDA Standard of Identity.

Only a product made from whole tomatoes may be called ketchup without qualification. The definition has specific requirements for label statements on ketchup made from other tomato constituents.

Pulp quality determines the final flavor, aroma and sensory quality of ketchup. Spices should be added in small amounts, with the intention of accentuating the tomato flavor, not masking it.

For inferior grades of ketchup made from poor pulp, the flavor of the pulp must be overcome by the spices, and the ketchup depends entirely upon them for its flavor.

Ingredients

Ketchup may be made directly from fresh juice or from concentrated pulp or bulk stored paste. The best quality tomato ketchup is made directly from clean, sound, fresh, ripe tomatoes with the addition of salt, sugar, vinegar, and spices, so that blending is done in one operation with the shortest possible heating time consistent with attainment of adequate keeping characteristics. There is better control of consistency, color, and flavor when ketchup is made from canned pulp and there is an economy achieved in heat, labor and materials.

General Operations

The preliminary steps in making ketchup and the equipment required are the same as those for making pulp. The selection of the tomatoes, their inspection, washing, steaming and pulping, or pulping raw are the same. From the time the tomatoes are emptied from the crate until the pulp is delivered to the cooking kettle, there should be no delay. The more time that elapses, and consequently the longer the exposure of the pulp to the air, the duller will be the final color. In conveying the pulp from one point to another, it should not come in contact with iron, and storage should preferably be in one of the improved metal tanks, glass lined tanks, or stainless steel. Both metals and oxygen exposure hasten color loss and off-color development in tomatoes.

Juice Extraction

The method is the same as that used in the manufacture of tomato juice.

A variation to the juice extracting process applicable to the manufacture of tomato paste, puree, and catsup has been recently introduced by the U.S. Department of Agriculture. This acidification process differs from conventional processes because it adds food grade hydrochloric acid to the crushed tomatoes to retain more of the natural pectin and solids normally lost in the liquid wastes. Pectin must be present in liquid tomato products to prevent the separation of solids from the liquid portion after processing. Heating at 200°F (93°C) stops all enzyme action which normally breaks down pectin. Hydrochloric acid may be added to the tomato material at a rate to obtain a pH no lower than 2.0±0.2. The subsequent addition of sodium hydroxide to the tomato material restores the product to its original pH and acid content. Acidification forms small amounts of common table salt and water. As in conventional processing, concentrating removes the excess water. The salt is not removed because its level is less than that normally required in catsups or in recipe and processed product uses of paste or puree.

The concentrated tomato products made by acidification have the same vitamin C and provitamin A content as products prepared by conventional processes. The color and flavor are also the same. Advantages of the acidification process is that it reduces solid wastes by as much as 35% and improves product quality and yields.

Ketchup From Aseptically Packed Tomato Pulp

Larger ketchup manufacturers in the U.S. are using tomato pulp that is aseptically packed in 55-gallon drums or bulk stored paste for ketchup production. (See chapter "Aseptic Processing and Packaging" in Books I and II respectively). Tank cars holding 20,000 to 40,000 gal. (75,700 to 151,400 L) are used to aseptically transport tomato pulp from "tank farms" to finished product plants. In tank farms the tomato pulp is aseptically stored in tanks of some 200,000 gal. (757,000 L) capacity. These tank farms are located in the major tomato production areas.

Formula

Nearly every manufacturer of ketchup has a formula which differs in some respect from those of other manufacturers. These differences are frequently in terms of the quantities of spices or other flavoring agents used.

The following formulae, which are based on suggestions made to the Department of Defense by a committee of ketchup manufacturers may be used as a working basis for manufacturing the type of ketchup desired. Formulas No. 1 and No. 2 are for ketchup with a light body, formula No. 3 for one with a medium body, and formula No. 4 for one with a heavy body. Ketchups made according to formulas No. 1 and No. 2 are too light in consistency for most commercial purposes and their use is not recommended except for special purposes.

TABLE 12.6 – Ingredients for Making 100 Gallons of Finished Product

	Formula No. 1	Formula No. 2	Formula No. 3	Formula No. 4
Cyclone juice (Sp. Gr. 1.020)	182 g* (689 L)	182 g* (689 L)	254 g* (961 L)	290 g* (1,099 L)
Cane sugar (or corn swtnr. equiv. of 58 or higher D.E.)	60 lbs. (27 kg)	75 lbs. (34 kg)	118 lbs. (54 kg)	150 lbs. (68 kg)
Salt	13 lbs. (6 kg)	15 lbs. (6 kg)	20 lbs. (9 kg)	24 lbs. (11 kg)
Vinegar (100 grain)	4 g* (15 L)	5 g* (19 L)	6.3 g* (23.8 L)	8 g* (30 L)
Onion, dehydrated (fresh equiv.)	Optional	Optional	27 lbs. (12 kg)	26 lbs. (12 kg)
Garlic, dehydrated (fresh equiv.)	Optional	Optional	4 oz. (113 g)	4 oz. (113 g)
Seasonings (Oleoresins, spice oils, or extracts of spices)	Sufficient to flavor as desired–see note below			

NOTE: ('g' denotes gallons). A pre-blended, custom formulated spice seasoning mix may be obtained from a seasoning manufacturer or spice company. It can be obtained batch-packed to accommodate the size of a processor's finished batch.

In these formulas it will be noted that the specific gravity of the cyclone juice is assumed to be 1.020. Where it runs higher than this the amount of cyclone juice used can be proportionally reduced. The amount of cyclone juice

in formulas No. 1 and No. 2 is equivalent to 100 gal. (378 L) of 1.035 pulp, in formula No. 3 to 140 gal. (530 L) of 1.035 pulp and in formula No. 4 to 160 gal. (606 L) of 1.035 pulp.

The following formula is said to give a good flavored ketchup with a heavy body:

TABLE 12.7 – Ingredients For Making 100 Gallons (378 L) of Finished Product

Cyclone juice	240 gal. (908L)
Cane sugar (or corn syrup equiv. of 58 or higher D.E.)	110 lbs. (50 kg)
Salt	24 lbs. (10.9 kg)
Vinegar, 100 grain	7 gal. (26.5 L)
Onion, dehydrated or fresh equivalent	25 lbs. (11.4 kg)
Garlic, dehydrated or fresh equivalent	10 oz. (284 g)
Seasonings (oleoresins, spice oils, or extracts of spices)	Sufficient to flavor as desired–see note

NOTE: A pre-blended, custom formulated spice seasoning mix may be obtained from a seasoning manufacturer or spice company. It can be obtained batch-packed to accommodate the size of a processor's finished batch.

Ingredients

The use of spice oils, oleoresins, and soluble and dry extracts of spices has become common because of the advantages of simple usage, easy dosification and low bacterial count. Spice firms pre-blend ketchup seasoning formulas using the above mentioned ingredients. These formulations may be obtained batch packed to accommodate the size of a processor's finished batch. The spice seasonings should be added to a cooking batch at the very end of a cooking cycle, immediately before turning off the steam, to prevent loss of volatile flavors.

Dehydrated onion or garlic, in powdered or granulated form, are reconstituted with water before being added to a batch of ketchup. Each pound of onion typically holds about 8 to 10 times its weight of water. It takes about 20 to 30 minutes to reconstitute.

The vinegar and sugar (or corn sweetener of 58 or higher D.E.) may be heated together and added to the batch as a hot syrup in order to avoid breaking the cook, and this should be done about five minutes before that operation is completed. If the vinegar is added too soon, much of the volatile acid is driven off. If the sugar or corn sweetener is added early, it tends to darken the product, but it should be added for a sufficient time to become thoroughly incorporated in the pulp as otherwise it may separate in the container. However, some packers add the sugar at the beginning of the concentration process and report improved color in the finished product.

Cooking

Ketchup is cooked in kettles and tanks of almost every size. Sometimes the desire for quantity outweighs that for quality; thus the batches are made too large or require too much time for completion. A number of cookers of about 250 gal. (946 L) capacity or less are preferred over larger sizes, although cookers of two or three times that capacity have also been used successfully. Such kettles are quickly filled, emptied and cleaned. Use of high steam pressure, 90–120 psi (620–827 kPa), should be available and is the best prevention against burning and sticking on the kettle or coils. A high heat insures circulation in the batch and in its absence the next best thing is to install a small high speed propeller in the cooker. Coils or kettles which are not self-cleaning delay the work and require a large amount of attention. The evaporation of a batch should not require more than 45 minutes. If whole spices are used it should not be less than 30 minutes.

When the kettle is first heated, foaming may occur, especially in pulp made from crushed tomatoes rather than those which are steamed to loosen the skins. Some varieties foam more than others. The use of compressed air is the best means of overcoming this foaming. The use of cottonseed or other oils or anti-foaming compounds will suffice where air is not provided.

As soon as the batch is finished the ketchup is run through the finishing machine and into the holding tank supplying the filling machine. The finishing machine removes all fiber and particles and gives a smooth body. Finishers vary in screen openings from 0.033–0.040 in. (0.084–0.102 cm).

The thickness of bottled ketchup is an important part of its quality. If it is too thick it will not pour well, while thin ketchup is distasteful. Control of consistency requires care and experience. Part of the thickness of properly made ketchup is due to the pectin from the tomatoes. If the pulp has been carelessly made there may be little if any of the original natural pectin remaining, and the pulp will be a watery mixture of tomato fibers in tomato liquid. Some ketchup manufacturers recommend a "hot-break" before the tomatoes are cycloned in order to retain as much as possible of the pectin from the tomatoes. The "hot break" process also dissolves some of the mucilaginous material from the tomato seeds which contributes to the final consistency.

Although the Standard of Identity for ketchup does not specify a minimum concentration, the U.S. Standards for Grades of Ketchup require Standard ketchup to have a specific gravity of at least 1.11 (corresponding to about 25% total solids), Extra Standard to have a specific gravity of at least 1.13 (corresponding to 29% total solids), and Fancy ketchup must have a specific gravity of at least 1.15 (about 33% total solids). The U.S. Standards for Grades also have definite color requirements.

The National Food Processors Association has published a bulletin entitled, "Tomato Products Tables." Several editions of that bulletin have been published, each time updating the information in accordance with changes in federal regulations. The data in "Tomato Products Tables" may be used to simplify the conversion of "salt-free" solids as specified in former standards of identity of tomato puree and paste to the "natural soluble tomato solids" specified in the new standards. The tables have application to tomato products containing total solids in the range from 4.0 to 50%.

Deaeration

For tomato ketchup packaged in glass, the use of a suitable deaerator is essential. The deaerator removes excessive amounts of air that may be incorporated in the ketchup during the finishing operation. Removal of the air prevents the occurrence of unsightly bubbles as well as product separation which will occur if the air content is too high. Air inclusion may also allow for oxidation of color compounds and off-flavor development due to lipid oxidation.

When using the deaerator, the ketchup flows from the finisher into a holding tank equipped with the necessary heating coils and a temperature controller to make certain the ketchup is at the proper temperature as it enters the vacuum deaerator. Normally this is approximately 200–205° F (93–96°C). The deaerator should be installed at a sufficient height above the filler bowl so that the ketchup may flow by gravity directly from the deaerator into the filler.

Glass Packaging

Bottles should pass through an inverting type of cleaner, which employs either air or hot water, prior to filling.

Preheating bottles is necessary to avoid excessive temperature differentials when hot ketchup is filled into the bottles, and also serves to prevent a colder bottle from cooling the hot ketchup too much before it is sealed. The preheater is essentially a tunnel with a sloping roof placed over the conveyor between the bottle cleaner and the filler. Perforated steam pipes are placed alongside the conveyor in the tunnel with the perforations directed downward so that steam surrounds the bottles without striking them directly. A similar perforated steam pipe with the holes directed laterally may also be added under the conveyor. The bottles should be preheated to a temperature of approximately 130°F (54°C) prior to being filled at 190°F (88°C).

Hot ketchup from the deaerator should be filled into the properly preheated containers at a temperature of 190–200°F (88–93°C), so that the temperature of the product in the center of the container is never lower than 190°F (88°C). Gravity fillers are normally used for filling ketchup in glass.

The filled containers should be sealed immediately with a positive hermetic seal. Plastisol lined lug caps are most widely used for ketchup today. They are available with a tamper-indicating button. Plastic caps are also being used. Cappers can be obtained from a cap manufacturer.

Cooling

From the capper, bottles will move directly into the cooler, typically spray coolers. The first section of the cooler will have either tempered water sprays or extremely fine sprays of cold water that produce a mist or fog. Where tempered water sprays are used, the water temperature in this first section (5 minutes in length) should be approximately 130-135°F (54-57°C).

In the second section of the cooler, successively heavier sprays of cold water can be used at a temperature of approximately 70-75°F (21-24°C) for an additional five minutes. The balance of the cooler should have heavy sprays at the normal plant water temperature.

Care must be taken to avoid any areas in the cooler where spraying is not adequate or the surface temperature of the bottles may rise again and the bottles may be subjected to an excessive temperature difference. Thus constant attention must be given to the condition of the spray nozzles.

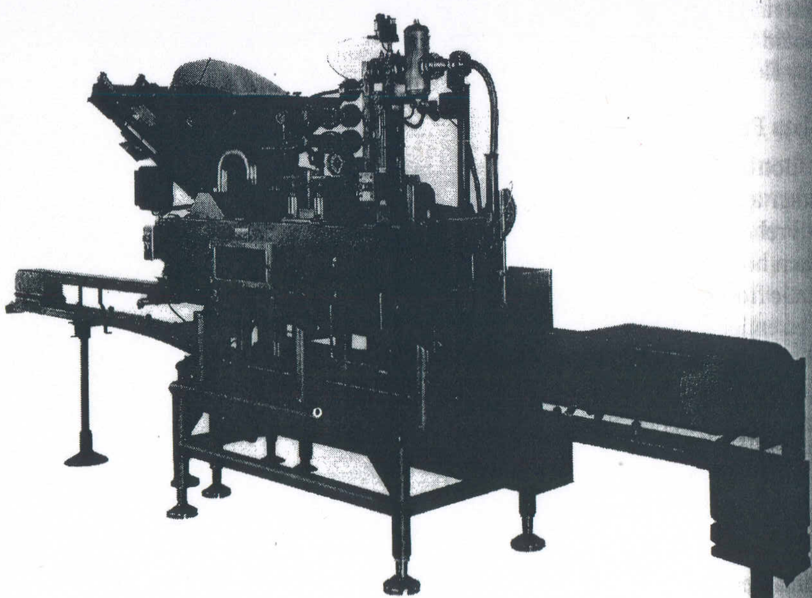

FIGURE 12.10 – Vapor-vacuum Capper and Filler in Ketchup Line (Courtesy White Cap Div., Continental Can Co.)

The bottles must be cooled to a point where the shake temperature is approximately 100°F (38°C). If the ketchup is not satisfactorily cooled down, and is immediately placed into cartons and then warehoused in a solid block, the residual heat left in the product will cause discoloration due to "stack burn."

If the bottles are cooled excessively, they may not dry properly prior to the labeling operation and difficulties may arise. Fans may be installed to blow off excessive water at the discharge end of the cooler to make the labeling operation easier. Air jets may also be installed along the conveyor between the cooler and the labelers to blow air under the closure and remove the water from this area.

COCKTAIL KETCHUPS

Cocktail ketchup, or cocktail sauce, differs from regular ketchup in that the body is generally thinner, less sweet and more pepper spices are added. The pepper may be added as fresh red peppers, crushed and ground sweet peppers, paprika, or cayenne.

Ingredients commonly include: 40 gal. (151 L) pulp (canned stock), 3 gal. (11 L) 60-grain vinegar, 2 pt. (0.9 L) Worcestershire sauce, 10 lbs. (4.5 kg) salted, ripe bull-nose peppers, 10 lbs. (4.5 kg) sugar, 6 lbs. (2.7 kg) salt, 6 lbs. (2.7 kg) onions, 1 lb. (0.45 kg) garlic, 3 lbs. (1.4 kg) peppers, 2 oz. (57 g) ground Saigon cinnamon.

Peppers are chopped fine and placed in the kettle with the chopped onions, garlic, peppers and pulp, cooked rapidly, and when the cook is half done, sugar and vinegar are added. Within five minutes of the end of the cook, cinnamon is added. Finally, the steam is turned off, the sauce added, then finished.

CHILI SAUCE

Chili sauce differs from ketchup in that the tomatoes are peeled and cored as for canning, the seeds are not removed and the tomatoes are chopped. Chili sauce generally contains more sugar and onions, and may be hotter due to the addition of cayenne pepper. Cooking and handling are the same as for ketchup, but the finishing operation is eliminated.

Chili Sauce has not been defined and therefore all of the ingredients must be stated on the label.

PIZZA SAUCE

As with puree, whole tomatoes are first washed and thoroughly sorted to remove undesirable fruit. The tomatoes then pass into a chopper pump which transports them, via a pipe, to a hot break tank. In some operations the tomatoes fall directly from the sorting belt into a hot break tank. The hot break process, as discussed earlier, operates most efficiently in an open system at near boiling temperatures. Another system has been developed which has been referred to as a "pressure break" or "super hot break" which can be carried out at a temperature above 212°F (100°C).

In the production of pizza sauce, crushed tomato stock in the hot break tank is transported to a pulper which is identical to a paddle finisher which has a screen size of $^3/_{16}$ in. (4.8 mm) or larger. This machine or a similar machine has the function of removing large pieces of core and stem material which might be undesirable in the finished product. The portion that passes through the screen consists of the thick pulpy portion of the tomato as well as a majority of seeds and some skin. This material, which has approximately 5-6% soluble solids, can then be transferred to a continuous vacuum evaporation system or it can be pumped into open kettles equipped with rotary system coils. It is concentrated like other tomato products. As with tomato pulp, pizza sauce is generally evaporated to a specific gravity of approximately 1.035 or, more importantly, to a consistency of 6 to 8 on a Bostwick Consistometer when measured hot. This instrument is used to determine the thickness of pizza sauce as it is being evaporated or boiled down. This value is naturally different from the value achieved by testing the finished product after being filled and cooled, i.e., as the temperature goes down in the pizza sauce the consistency of the product increases. Commercial pizza sauce is generally sold on the basis of consistency and not specific gravity. After the sauce has been evaporated to the desired thickness level, the other ingredients are then added to the boiling mass to ensure uniform distribution. Some manufacturers use a suitable thickener, such as a starch, which is soluble at high temperatures.

Commercial pizza sauce may be sold in a number of different forms from regular pizza sauce which has little or no seasonings, to a fully prepared pizza sauce which might have a recipe similar to the following:

TABLE 12.8 – 600-Gallon Batch of Pizza Sauce

Granulated Sugar	45 lbs. (20.5 kg)
Salt	45 lbs. (20.5 kg)
Chopped Onion	10 lbs. (4.5 kg)
Granulated Onion	10 lbs. (4.5 kg)
Ground Black Pepper	6 lbs. (2.7 kg)
Garlic Powder	6 lbs. (2.7 kg)
Leaf Oregano	6 lbs. (2.7 kg)
Vegetable Oil	2 gal. (7.6 L)
Olive Oil	$^2/_3$ gal. (2.5 L)
Red pepper, dry	4 oz. (113 g)
Oil of Oregano	10 ml
Oil of Sweet Basil	10 ml

These ingredients are premixed with water in a mixer or ribbon blender. They are then added to the boiling mass of crushed tomato. It is important to turn off the steam in this cook tank as soon as possible to prevent the volatile portion of the seasonings from being lost with the steam. The product is transferred to a holding tank, run through a heat exchanger, and is then pumped to the filling and closing equipment in a hot fill and close operation. Pizza Sauce is sold in a variety of containers, such as glass jars, metal cans, plastic bags, 3-gallon (11 L) bags, 55-gallon (208 L) drums, or in bulk.

ACKNOWLEDGEMENT

The author thanks Robert C. Pearl of the Department of Food Science and Technology for his contribution to earlier editions of this chapter, and Diane M. Barrett, Ph.D., Department of Food Science and Technology, University of California, Davis for the revision of this chapter, as well as William J. Hirzel, Hirzel Canning Company for his contribution on the section on Pizza Sauce.

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