**6. Fruit Juice Production Technology**

Juice; It is an unfermented but fermentable product obtained from the edible parts of a single fruit or of a mixture of more than one fruit, which is firm, ripe, fresh or preserved in cold or freeze, and has the characteristic color, aroma and taste of the fruit or fruit from which it is obtained[5].

The juice can be processed as clear, cloudy or nectar type. Clear type fruit juices (cherry, grape, pomegranate, apple, etc.) are clarified fruit juice with 100% fruit ratio. On the other hand, cloudy type fruit juices (citrus fruits) are fruit juices that become tasteless when clarified and therefore are not clarified. In processing fruit into nectar (strawberry, apricot, peach, plum, cranberry, tomato, pear, etc.), sugar, acid and water are added in addition to the process, and the fruit rate is between 25-50%[5].

Pome fruits (soft seeds) such as apple, pear, quince, etc., stone fruits (cherry, apricot, peach, etc.), grape (grape, strawberry, raspberry, blackberry, etc.), citrus (orange, lemon, mandarin, grapefruit, etc.) or tropical (mango, pineapple, papaya, passion fruit etc.) fruits can be processed.

**6.1. Pre-treatments**

Unripe, overripe, rotten, dented and damaged fruits are separated from the fruits. Then, foreign materials such as straw, trash, metal, leaves are removed. Afterwards, the fruits are washed to remove dust, soil, pesticide residues, etc., and the microorganism load is reduced at this stage.

The washed fruits are either pressed to extract the juice or conveyed to the palper to be crushed. However, pre-pressing should be done in order to preserve quality criteria such as color and flavor and to increase efficiency by facilitating other stages of the process[5].

The classification stage from the pre-processes is important in citrus fruits. In order to eliminate the difficulties that may occur during the pumping and transfer of the mash to the pressing, stalk separation is performed. Only stone fruits that will be pulped are removed from the core, thus facilitating the disintegration of the fruit and the pumping of the mash, the problems caused by the seeds in heating are eliminated and the unwanted substances in the core are prevented from entering the pulp[76].

After all these processes, soft fruits are shredded by revolving knives and hard fruits are shredded in special meat grinders and the smashed fruit is called mash. If the shredding is too fine, pressing and clarification becomes difficult, and if it is too coarse, the juice yield decreases. Therefore, this process should be done with care. Citrus fruits are not crushed, as it is not desired that the oil in the skin of the citrus passes into the product and impairs the sensory properties. To prevent oxidative browning reactions in light colored fruits, ascorbic acid can be added as soon as the fruit integrity is lost[5,77].

The obtained mash is heated in a tubular heater at 85-57°C for 2-3 minutes. A good mash heater should be able to heat the mash quickly and indirectly. Thus, enzymes become inactive, fruit juice yield increases, the color substances in the skins of the fruits pass into the fruit juice and the microorganism load decreases. However, the mash of fruits such as apple, pear, quince, which will be processed into clear fruit juice, which will lose their pressing feature, is not heated. The mash must be heated as it prevents the separation of pulp in the fruit to be pulped and serum in the nectars produced from them. Here, thanks to the heat treatment that leads to pectolytic enzyme inactivation, the pectin structure is preserved and the pulp structure becomes stable. If the fruit pulp is to be processed after the mash is heated, the mash is palpated without cooling and processed hot. On the other hand, if mash enzymation is to be applied, the mash is cooled to 50°C. The enzymatic fermentation of mash is done into clear juice to improve press quality and increase yield. In this process, 3-5 grams/ton powder or 20-30 ml/ton liquid pectolytic enzymes are added to the mash taken into the tanks and left for 1-2 hours. For this purpose, polygalacturonase, pectalyase, pectinase, pentinelyase, pectinesterase, celluloses or hemicelluloses can be used. With these enzymes, both clarity is provided and the color materials are transferred to the fruit juice[78-80].

**6.2. Pulp Processing of Mash**

The pulp is the part of the fruit that is free from the skins, coarse fibers and seeds and seeds as in fruits such as tomatoes and strawberries. Peach, apricot, cherry, plum, cranberry, pear, guava, mango, papaya, banana are examples of fruits whose pulp is processed.

The mash is shredded in the pulper during pulp processing. Fruit crushers can have 1, 2 or 3 stages and the final thinning stage is called the finisher. In pulp production, the heated mash is given to the palper without cooling, so that the system is covered with steam and the pulp is not mixed with air. The pulp obtained should be cooled to 20-25°C in a tubular cooler and processed into nectar immediately. If the pulp is not to be processed immediately, it should be stored by deaerization, pasteurization or sterilization and aseptic filling, respectively[5].

**6.3. Juice Seperation from Mash**

Raw juice from the mash is obtained by presses, rotary vacuum filters or total liquefaction. Clear and naturally turbid juices are pressed, juices taken from the press and juices taken from the extractor are turbid. If clear fruit juice is to be produced, it is passed through a centrifuge or decanter to separate coarse sediment and clarified.

In the production of fruit juice in rotary vacuum filters, the viscous mash is diluted and further liquefied with the help of pectolytic enzyme, and clear fruit juice is obtained by passing through a rotary vacuum filter. In the total liquefaction method, the cell wall is broken down enzymatically and the tissue is completely liquefied. Extractors are used in the juice produced from citrus fruits[5,77,78].

**6.4. Clarification Process**

Pressed juice can also be bottled as it is, but is usually clarified to improve appearance. The purpose of this process is to produce stable and clear juice by neutralizing the compounds that cause turbidity (pectic substances, polyphenols, starch, proteins, cellulose, etc.). Besides, juices are mostly stored as concentrates. Non-enzymaticly treated concentrates becomes jelly. Clarification process is done in two stages, depectinization and clarification. Depectinization is the first stage of clarification and pectin and starch are broken down by adding pectolytic enzyme and amylolytic enzyme to the juice. When complete disintegration occurs, the clarification process in Stage 2 is applied. In this process, flocculation is made by adding clarification aids and precipitating very fine-grained elements in colloidal structure. At this stage clarification aids such as gelatin, kizelsol, bentonite etc. are used. Cold clarification takes approximately 6 hours at 2 °C, and hot clarification takes approximately 2 hours at 50°C [79,80].

**6.5. Filtration Process**

Clarified juice can only be filtered to achieve full clarity. In all processes, whether conventional or membrane filtration is applied, first a coarse filtration and then a fine filtration process is performed. Filter aids such as kieselguhr, perlite or cellulose fibers are used to prevent the filter from being blocked by turbidity elements. Kieselguhr filters are the most commonly used but cannot provide crystal clarity. With plate filters, coarse, fine and sterile filtration is also possible, along with crystal clearness. Membrane filters are very advanced techniques and ultrafiltration or microfiltration is generally applied in clear filtration. Reverse osmosis process is preferred in the fruit juice to be concentrated[81].

**6.6. Concentration, Storage and Packaging of Fruit Juices**

With the concentration process, the dry matter of fruit juices is increased to approximately 60-75%. Thus, the concentrate is made more stable microbiologically and chemically, and the storage and transport volume of the product is also significantly reduced. Fruit juices can be concentrated by freezing, reverse osmosis or evaporation. All citrus concentrates and concentrates produced under 680 brix are stored frozen between -18°C and -20°C, while concentrates above 680 brix are stored cold below 10°C[82,83].

Before being packed into the package, standardized fruit juices are subjected to heat treatment and packaged under aseptic conditions. Depending on the juice type, addition of water, acid, sugar, etc. may be permitted to clear or cloudy juice. While no additives can be added, only water and flavoring agents can be added to the concentrates[5]. Since the pulp is not very thick and drinkable in terms of taste, acid and sugar can be added to balance the flavor while adding water. The product obtained in this way is called nectar. When processing pulp nectar, attention should be paid to the fruit ratio. In order to avoid solid-liquid phase separation problem in these products, homogenization process is applied in order to reduce the size of the particles causing suspension and to prevent phase separation. Then, the oxygen in the structure should be removed as it causes problems such as browning, foam formation, errors in the filling volume and phase separation. For this purpose, the deaeration process is applied[76].

**6.7. Heat Treatment, Filling and Storage**

In order to prevent deterioration in fruit juices and to eliminate health risks, heat treatment is applied. Whatever the method of applying heat treatment (conventional-bottle pasteurization, hot filling or aseptic filling) it should be done at the same time as filling the packaging material[5,83].

Cardboard boxes, glass or plastic bottles, bag-in boxes, metal boxes, barrels or tanks are mainly used for packaging fruit juices.

Filled fruit juices and products are labeled and shipped to the warehouse. Fruit juices produced in the press line are stored at +4°C and below, and those produced in the pulp line are stored at approximately 20°C. Concentrates obtained from the citrus line are cooled and stored at -18 and -20°C. Bottled and crated fruit juices are kept in storage at around 20°C until they are sold[84].