

Preparing Shelf-Stable Citrus Juice and Drinks at Home

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Citrus Fruit and Products

Citrus fruit is subtropical fruit including orange, tangerine, mandarine, clementine, grapefruit, lemon, lime, calamansi, and pummelo. Citrus fruit can be processed into single-strength, concentrated, refrigerated, frozen, and shelf-stable juice in various packages. Citrus juice can also be made into citrus drinks, such as lemonade, limeade, nectar, lemon tea, and lemon cocktail. Due to the popularity and health benefits, citrus juice and drinks account for about 70% of all fruit and vegetable juice in U.S.

Calamansi, key lime, and lemon are the three major citrus fruit on Guam. Although they are year-round fruit on the island, their peak harvest season is from March to July. There is an opportunity to process citrus fruit juices and drinks on Guam for consumption throughout the year.



Fig. 1. Calamansi fruit and drink.

Anatomy and Composition of Citrus Fruits

Generally, citrus fruit contains 40-45% juice, 8-10% flavedo (outer peel), 15-30% albedo (inner peel), 20-30% rag, and 0-4% pulp and seeds. Citrus juice

consists of water, sugar, polysaccharides, vitamins, organic acids, carotenoids, flavonoids, flavor compounds, and bitter components.

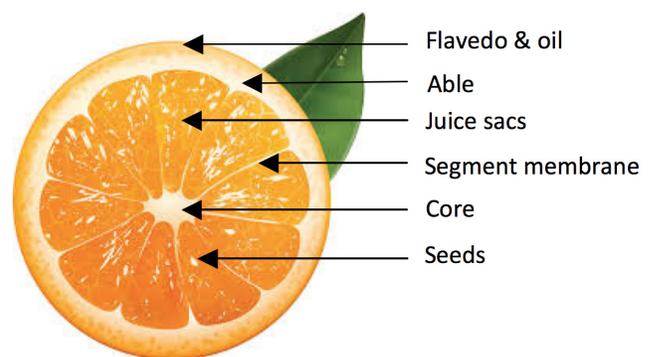


Fig. 2. Components of orange fruit.

Orange, calamansi, lemon, and lime juices have a soluble solid content (or sugar content) of 11.8, 9.0, 4.5, and 4.5 °Brix, a pH value of 3.30-4.19, 2.40-3.00, 2.00-2.60, and 2.00-2.80, and titratable acidity (citric acid) of 0.55-1.04, 4.50-5.80, 4.40-4.57, and 5.00-6.00%, respectively. The soluble solid and acidity of citrus fruit juice changes with time during the year. Harvesting citrus at the optimal time during the year is critical for juice quality.

Processing Single-Strength Citrus Juice

Single-strength citrus juice is the juice extracted or pressed from the fresh citrus fruit. The fresh citrus juice has unique citrus flavors with various nutrients. The following flowchart shows the major procedures for processing fresh single-strength citrus juice at home.

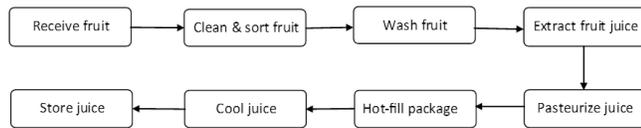


Fig. 3. Flowchart of processing cloudy single-strength citrus juice.

Quality of Fruits

Fruit quality determines juice quality. Using mature and sound quality fruit is critical to process high quality citrus juice. Citrus are non-climacteric fruit, meaning that they do not ripen any more after harvest. Therefore, citrus fruit must be ripe on the tree and harvested at a time when sugar content, acidity, color, flavor, and firmness are best for juice processing. During harvest, transportation, and storage the fruit must be carefully handled to maintain freshness and quality. For example, in storage, the temperature, humidity, and cleanliness should be controlled to prevent fruit decay and damage caused by bacteria, molds, yeasts, insects, and other pests.

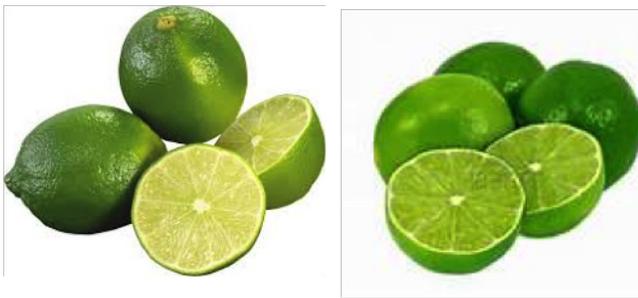


Fig. 4. Local green lemon and key lime.

Fruit Inspection

Citrus to be juiced can be from either field or packing house. For fruit from the field, remove leaves, stems, and twigs as well as inferior, broken, and decayed fruit. From the thoroughly washed fruit, select those with good size, weight, and color and contain high amounts of juice ($^{\circ}$ Brix).

Citrus Juice Extraction

Juice can be extracted manually or machinery. For large scale juice processing, the most common juice extractors are the FMC cup extractor (John Bean Technologies Corporation) and the Brown reamers extractor (Brown International Corporation). About 75% of the world citrus juice industries use FMC cup ex-

tractors. For small scale juice processing, juice extractors are operated by pressing, centrifuging, or reaming. Many small scale juice extractors are available for juicing at home, retail, or manufacturing locations.



Fig. 5. Fruit juice extractors.

Function of Pectin in Citrus Juice Processing

Pectin is a carbohydrate polymer used to stabilize the cloudiness of citrus juice. Pectinesterase (PE) is an enzyme that changes the pectin molecule to pectinic acid. The pectinic acid can combine with calcium in citrus juice to form insoluble calcium pectate, which clarifies the cloudiness of citrus juice. To process cloudy citrus juice, PE must be inactivated by heat treatment at 85-90 $^{\circ}$ C (185-194 $^{\circ}$ F) for 15 seconds. To process clear citrus juice, PE and calcium can be added to precipitate pectin and remove the cloudiness of the juice.

Pasteurization

The purpose of pasteurizing citrus juice is to kill pathogenic and spoilage microorganisms. Since citrus juice is an acid food ($\text{pH} < 4.6$), only the destruction of vegetative cells of microorganisms is required. According to the US Food Drug and Administration (FDA) regulation regarding to process fruit and vegetable juices, Hazard Analysis and Critical Control Point (HAACP) requires killing pertinent microorganisms, such as Salmonella, by achieving a 5-log reduction of the initial pathogen population. A 5-log reduction means that the number of bacteria is reduced by 99.999%. For example, the number of cells is reduced from 100,000 to 1. Pasteurization of citrus juice at 71-73 $^{\circ}$ C (160-163.4 $^{\circ}$ F) for 15 seconds meets the requirement of 5-log reduction.

In processing cloudy citrus juice, the heat treatment (85-90°C or 185-194 °F for 15 seconds) to inactivate PE (pectinesterase) can achieve more than 5-log reduction in killing vegetative pathogens and spoilage bacteria.

Hot Fill Packaging

After pasteurization, citrus juice must be packed immediately to prevent the loss of quality and to protect the juice from contamination. Hot-filling is a typical method used in small production to pack fruit juice or drinks. The hot-fill packing includes three steps: (1) fill the pasteurized hot juice of 88-95 °C (190-203 °F) immediately into bottles, jars, or cans; (2) seal the bottles, jars, or cans with clean and sanitized lids; and (3) invert the container for three minutes to pasteurize the inside of lids with the juice's high temperature. Glass bottles, polyethylene terephthalate (PET) hot-packed plastic bottle, or mason jars can be used for hot-filling citrus juice or drinks.



Fig. 6. Polyethylene terephthalate (PET) plastic bottles for hot-packed beverage.

Cooling and Storage

After hot-filling, cool the bottled juice to room temperature. Chlorinated water (200 ppm, 1 tablespoon of chlorine bleach per gallon of water) can be sprayed on bottles, cans, or jars to speed the cool process. The hot-fill-packed juice or drink can be stored at room temperature or in the refrigerator or freezer. Since the flavor and nutrient profiles of juice change during storage, refrigerated and frozen citrus juice maintains higher quality and has a longer shelf-life than juice stored at room temperature. Generally, the shelf-life of citrus juice is about 9-12 months at 15-20 °C (59-68 °F) or 1-2 years at 0-4 °C (32-40 °F) or at -18 °C (0 °F), respectively.

Federal and Regional Food Safety Regulations

Foodborne illness outbreaks of fresh orange juice are associated with pathogens such as *Salmonella* spp., *Escherichia coli* O157:H7, and *Cryptosporidium parvum*. The FDA requires a written HACCP plan to process fruit juice safely. In the HACCP plan for fruit juice, the thermal pasteurization should achieve a 5-log reduction (99.999%) for pertinent pathogens (such as *Salmonella* spp.), e.g. at 71-73 °C (160-164 °F) for 10 seconds.

To process and market food products on Guam, all plants or manufactures are required to follow regional food safety regulations. The Guam Department of Public Health and Social Services (DPHSS) conducts inspections and issues permits to processors for food product processing on Guam. All manufactures should contact DPHSS for a permit to process and market citrus juice on the island.

Table 1. Procedures to Make Single Strength Calamansi, Keylime, and Lemon Juice

Procedure	Application
Clean and sort fruit.	Remove leaves, stems, and twigs. Remove inferior, broken, and decayed fruit.
Wash fruits thoroughly.	Use clean tap water.
Extract juice with a juice extractor.	If needed, cut fruit into half, especially for key lime and lemon.
Pasteurize the juice at 95 °C (203 °F) for 15 sec.	Heat the juice in a pot, stir constantly, and check temperature with a thermometer.
Hot-fill the pasteurized juice immediately in bottles or jars.	Maintain the juice at temperature of 88-95 °C (190-203 °F) during packing.
Invert bottles or jars for 3 minutes.	Pasteurize the lids by the high temperature of the juice.
Cool the juice to room temperature.	Cool the juice naturally or spray the bottles or jars with chlorinated water (200 ppm).
Store the juice in the refrigerator or at room temperature.	Refrigeration is suggested to maintain good quality and nutrients of the juice.
Consume the juice within 1 year.	The refrigerated juice may have a shelf-life of 1-2 years.

Recipes for Making Calamansi Drink, Lemonade, and Limeade

Single-strength calamansi, lemon, and key lime juice is too sour to consume directly. However, you can use the single-strength juice to make calamansi drink, lemonade, or limeade. The recipes in Table 2 are recommended to make these citrus drinks. Use the recipe either based on cups or grams to make the citrus drinks. Instead of sugar, add honey, other sweetener, or flavors. The prepared drinks can be consumed directly or pasteurized and packed using the hot-filling method for later consumption.

Table 2. Recipes Using Single-Strength Citrus Juice to Make Calamansi Drink, Lemonade, and Limeade.

Ingredients	Calamansi drink	Lemonade	Limeade
Single strength juice ¹	2 cups (500 g)	2 cups (500 g)	2 cups (500 g)
Sugar ²	2.5 cups (200 g)	4.5 cups (360 g)	4.5 cups (360 g)
Water ¹	6 cups (1,500 g)	10 cups (2,500 g)	10 cups (2,500 g)

¹Use liquid measuring cup. ²Use solid measuring cup.

Recipes for Processing Calamansi, Keylime, and Lemon Drink-Bases

For convenient consumption, single-strength citrus juice can be used to make shelf-stable citrus drink-bases. The recipes are recommended in Table 3. After preparing the citrus drink-base, pasteurize, hot-fill pack, and store the drink-base as described in juice processing. Before consumption, add drinking water at 3 times (volume) of the calamansi drink-base or 5 times (volume) of the lemonade base or limeade base and then mix and enjoy.



Fig. 7. Lemonade.



Fig. 8. Calamansi drink.

Table 3. Recipe Using Single-Strength Citrus Juice to Make Calamansi Drink-Base and Lemonade and Limeade Base for Hot-Filling Package.

Ingredients	Calamansi drink-base	Lemonade base	Limeade base
Single strength juice ¹	2 cups (500 g)	2 cups (500 g)	2 cups (500 g)
Sugar ²	2.5 cups (200 g)	4.5 cups (360 g)	4.5 cups (360 g)

¹Use liquid measuring cup. ²Use solid measuring cup.

Yield of Local Citrus Juice and Drinks

The yield of single-strength juice from fruit of calamansi, key lime, and lemon is about 45%. Based on the weight of fruit (1 kg or 2.2 lbs), with the recommended recipes, a yield of 1.8 kg or 4.0 lbs (180%) for calamansi drink and 2.7 kg or 6.0 lbs (270%) for limeade and lemonade can be achieved.

References

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