MINISTRY OF FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

PM Formalisation of
Micro Food Processing Enterprises (PM-FME) Scheme
Handbook Of
Processing of Fortified Citrus Lemon Juice

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1. Introduction

Background

India ranks second for fruits and vegetables producer in the world followed by China. India, during 2017-18 has produced about 97358 thousand MT fruits and 184394 thousand MT vegetables in about 6506 Thousand Ha and 10259 Thousand Ha respectively (Horticulture statistics At a glance, 2018, MoA & FW Gol). In spite of this, the per capita availability of fruit in india is 107 gm/day which is below the recommended 120 gm/day. India's share of global exports of fresh fruits and processed fruit products is also quite meager compared to other major fruit producers of the world (Bung, 2012). Unfortunately, fruits and vegetables being perishable in nature get wasted to the tune of 20-30 % in the supply chain due to improper handling, transportation and poor post-harvest management; and only 2 % of them are processed in to value added products and the rest is consumed fresh. Lemon is the third most important citrus fruit following orange and mandarin. Fruits of lemon plants are appreciated for their high content of flavonoids, vitamin C, citric acid and minerals.

Lemon (Citrus limon Burm. f.) is the medicinally important plant and belongs to the family Rutaceae. Lemon is the third most important citrus fruit following orange and mandarin. The origin of the lemon is unknown, though lemons are thought to have first grown in Assam (a region in northeast India), northern Burma or China. A genomic study of the lemon indicated it was a hybrid between bitter orange (sour orange) and citron. Citrus fruits are native to south-eastern Asia and are among the oldest fruit crops to be domesticated by humans. They are widely grown in all suitable subtropical and tropical climates and are consumed worldwide. Citrus lemon spread all across Middle East, Europe, Africa and as far as Americas. Lemons entered Europe near southern Italy no later than the second century AD, during the time of Ancient Rome. However, they were not widely cultivated. They were later introduced to Persia and then to Iraq and Egypt around 700 AD. The lemon was first recorded in literature in a

10th-century Arabic treatise on farming, and was also used as an ornamental plant in early Islamic gardens. It was distributed widely throughout the Arab world and the Mediterranean region between 1000 and 1150. The first substantial cultivation of lemons in Europe began in Genoa in the middle of the 15th century. The lemon was later introduced to the Americas in 1493. It was mainly used as an ornamental plant and for medicine. In the 19th century, lemons were increasingly planted in Florida and California. . Total Lemon production in India is about 3147.85 MT. Top lemon producing states are Gujarat, Andhra Pradesh, Madhya Pradesh, Karnataka, Orissa and Maharashtra. Gujarat contributes 20 % share of total lemon production in India followed by Andhra Pradesh accounting for 18%, Madhya Pradesh and Karnataka accounting for 10% of Total lemon production in India.

Citrus lemon is the most important fruit in all over world. It is well known for nutritional and medicinal property. All citrus lemon is used as a traditional medicine. Citrus lemon fruit is used for culinary and non-culinary purposes throughout the world, primarily for its juice, which has both culinary and cleaning uses. The pulp and rind are also used in cooking and baking. The juice of the lemon is about 5% to 6% citric acid, with a pH of around 2.2, giving it a sour taste and which is also rich in vitamin C and contains smaller amounts of Vitamin B, particularly thiamine, riboflavin, and niacin.

Cultivation

Citrus Lemon is a small evergreen tree in the family Rutaceae grown for its edible fruit which, among other things, are used in a variety of foods and drinks. The tree has a spreading, upright growth habit, few large branches and stiff thorns. The tree possesses large, oblong or oval, light green leaves and produces purple-white flowers in clusters. The lemon fruit is an ellipsoid berry surrounded by a green rind, which ripens to yellow, protecting soft yellow segmented pulp. Lemon trees can reach 3–6 m (10–20 ft) in height and can live for many years, reaching full fruit bearing capacity in approximately 40 years. Lemon may also be referred to as bush lemon or Persian apple and likely originated from the eastern Himalaya of India.

There are different varieties of Citrus lemon found across world.

The ‘Bonnie Brae’ is oblong, smooth, thin-skinned and seedless. These are mostly Sgrown in San Diego County, USA.

The 'Eureka' grows year-round and abundantly. This is the common supermarket lemon, also known as 'Four Seasons' because of its ability to produce fruit and flowers together throughout the year. This variety is also available as a plant to domestic customers. There is also a pink-fleshed Eureka lemon, with a green and yellow variegated outer skin. They are commercially popular because of their reliable flavor and continuous growing season.

The Lisbon lemon is very similar to the Eureka and is the other common supermarket lemon. It is smoother than the Eureka, has thinner skin, and has fewer or no seeds. It generally produces more juice than the Eureka.

The ‘Meyer’ lemon is not ‘true’ lemon, but hybrid which is originated from China. It is a cross between a lemon and a sweet orange such as a mandarin. It looks like lime when young, rounder than true lemons and with a lime green skin. As the lemon ripens, it takes on the typical yellow shade, with a strong fragrance and thin skin. These lemons have a more subtle flavor than the Eureka or Lisbon lemons, which are widely available in grocery stores. Instead, they have a sweeter taste, with a dark yellow flesh and usually around 10 seeds.

Primofiori Lemon is grown extensively in the Mediterranean region and is the most largely commercially produced lemon in Spain. The trees have a vigorous growth habit, with large leaves and dense foliage. The fruit it produces is pale yellow in color, with a thin and smooth skin. Lemons can be round or oval, and are smaller in size than most other lemon varieties, though they tend to be much juicier.

Verna This lemon tree is native to Spain, where it is the second most important lemon tree after the Primofiori. It is widely known as both Verna and Berna. The fruits of this tree are less appealing for consumption than other lemons, as they tend to have a thick rind and do not contain much juice. This lemon is ornamentally attractive.

The 'Sorrento' is native to Italy. This fruit's zest is high in lemon oils. It is the variety traditionally used in the making of *limoncello* (Italian lemon liquor).

The 'Yen Ben' is an Australasian cultivar.

Lemon is a subtropical plant and the trees grow best in regions with a pronounced change in season. They will grow best at temperatures between 26–28°C (79–82°F) and are very sensitive to cold. Trees and fruit will be damaged or killed by freezing conditions without protection. The trees will tolerate drought conditions but perform poorly in water-logged soil. Trees will grow best when planted in a well-draining sandy loam with a pH between 6.0 and 7.5. Soil must be deep enough to permit adequate root development. Lemon trees will grow best when positioned in full sunlight. Lemon trees for commercial planting are usually propagated by grafting or budding the desired variety on seedlings of other *Citrus* species, such as the sweet orange, grapefruit, mandarin orange, sour orange, or tangelo.

Newly planted trees require proper irrigation to ensure they become established. During the first year, water should be applied at the base of the trunk so that the root ball is kept moist to allow the roots to establish in the soil. Newly planted trees should be provided with water every 3–7 days. The soil should be moist, but not wet. Trees planted in sandy soils will require water more frequently. Young trees will also require a light application of fertilizer every month in the first year. Lemon trees will need protected from cold temperatures to prevent damage. Soil can be mounded up around the trunk during the winter and removed in the spring. Young trees can also be protected from frosts by covering them with tarps or blankets as required.

Post-harvest Management:

There are some fruit handling management after harvesting to avoid post-harvest losses. Following are Post-harvesting handling practices:

- Do not leave harvested fruit out in the hot sun;
- Do not pick cold, wet fruit. When wet turgid fruit is handled the oil Glands can be ruptured. The released oil burns the fruit surface (oleocellosis) and also stimulates fungal spores to germinate. The burn Marks can take 2-3 days to develop;
- Wear cotton gloves when harvesting. This reduces puncture marks from Fingernails and jewellery;
- Use picking bags. This reduces damage as a result of abrasion on Wooden or metal picking bins and allows fruit to be gently lowered into Bulk harvesting bins;
- Do not leave stems on fruit or damage buttons by "plugging";
- Use clean, smooth harvesting bins;
- Make sure packing line equipment is cleaned regularly. This reduces dirt And wax buildup which can cause fruit abrasion;
- Reduce packing line abrasion by using foam, rubber and smooth belts to Cushion fruit;
- Remove old and rotten fruit regularly from the packing shed and surrounds;
- Treat harvested fruit with a registered fungicide within 24hrs of harvest;

Nutrition

Lemon

Lemon is a great source of vitamin C and fibre, lemons contain many plant compounds, minerals, and essential oils. Lemons contain very little fat and protein. They consist mainly of carbs (10%) and water (88–89%). The carbohydrates in lemons are primarily composed of fibres and simple sugars, such as glucose, fructose, and sucrose. The main fibre in lemons is pectin. Soluble fibres like pectin can lower blood sugar levels by slowing down the digestion of sugar and starch. Dietary fibres are an important part of a healthy diet and linked to numerous health benefits. It also rich in following vitamins and minerals.

- **Vitamin C.** An essential vitamin and antioxidant, vitamin C is important for immune function and skin health.
- **Potassium.** A diet high in potassium can lower blood pressure levels and have positive effects on heart health.
- **Vitamin B6.** A group of related vitamins, B6 is involved in converting food into energy.

The carbohydrates in lemons are primarily composed of fibers and simple sugars, such as glucose, fructose, and sucrose. The plant compounds in lemons and other citrus fruit may have beneficial effects on cancer, cardiovascular disease, and inflammation.

These are the main plant compounds in lemons:

Citric acid. The most abundant organic acid in lemons, citric acid may help prevent the formation of kidney stones.

Hesperidin. This antioxidant may strengthen your blood vessels and prevent atherosclerosis — the buildup of fatty deposits (plaque) inside your arteries.

Diosmin. An antioxidant used in some drugs that affect the circulatory system, it improves muscle tone and reduces chronic inflammation in your blood vessels.

Eriocitrin. This antioxidant is found in lemon peel and juice.

D-limonene. Found primarily in the peel, d-limonene is the main component of lemon essential oils and responsible lemons' distinct aroma. In isolation, it can relieve heartburn and stomach reflux.

Nutritional value per 100 g

Nutritional Parameters	Values	% of Daily value
Calories	29 Kcal	-
Total Fat	0.3 g	-
Saturated Fat	0 g	-
Trans Fat	0 g	-
Polyunsaturated Fat	0.1 g	-
Mono saturated Fat	0 g	-
Cholesterol	0 mg	-
Sodium	2 mg	-
Potassium	138 mg	4 % of DV
Total Carbohydrates	9.3 g	3% of DV
Dietary Fibre	2.8 g	11 % of DV
Sugars	2.5 g	-
Protein	1.1 g	-
Vitamin A	-	0.4 % of DV
Vitamin C	-	88 % of DV

Calcium	-	2 % of DV
Iron	-	3.3 % of DV

Source: USDA Nutrient Database

Constituents and Health Benefits of Citrus lemon

Lemon also have many potential health benefits. Eating lemons may lower your risk of heart disease, cancer, and kidney stones. A medium lemon provides only about 20 calories.

Health benefits:

1. Heart health: Intake of fruits high in vitamin C is linked to reduced heart disease risk; Intake of isolated fibres from citrus fruits has been shown to decrease blood cholesterol levels, and the essential oils in lemons can protect LDL (bad) cholesterol particles from becoming oxidized. Flavonoids in citrus fruits may help lower the risk of ischemic stroke in women. Long term, regular consumption of foods that contain flavonoids might help protect against cancer and cardiovascular disease. Potassium may help lower the risk of stroke.

2. Blood pressure: Consuming lemon can help reduce blood pressure.

3 Cancer prevention: Lemons and lemon juice are an excellent source of the antioxidant vitamin C. Antioxidants may help prevent free radicals from causing cell damage that can lead to cancer.

4 Prevent asthma: vitamin C also benefitted people with bronchial hypersensitivity when they also had a common cold and people with asthma.

5 Anemia prevention: Anemia is often caused by iron deficiency and most common in pre-menopausal women. Lemons contain small amounts of iron, but they are a great source of vitamin C and citric acid, which can increase the absorption of iron from other foods. It may help prevent anemia.

6. Prevention of kidney stones: The citric acid in lemons may reduce your risk of kidney stones by diluting urine and increasing its citrate content.

7. Boosting the immune system: Foods that are high in vitamin C and other antioxidants may help strengthen the immune system against the germs that cause the common cold and the flu.

8. Maintaining healthy complexion: Vitamin C plays a vital role in the formation of collagen, the support system of the skin. Sun exposure, pollution, age, and other factors can result in skin damage. By eating vitamin C in its natural form or applying it topically can help prevent this type of damage.

9. Weight loss: Lemon detox diet resulted in greater improvements in insulin resistance, body fat, BMI, body weight, and waist-hip ratio than those on the other diets.

10. Scurvy: Scurvy is caused by deficiency of Vitamin C, connective tissues weaken due to the lack of vitamin C. Consumption of lemon of vitamin prevent scurvy.

Value Added lemon Products

Lemon constitutes an important fresh fruit group even though it is not eaten fresh as mandarins and oranges. They usually have high acid content although acid less cultivars also exist. It is used primarily for drinks and fresh juice or lemonade, cooking

and flavoring, especially in the making of lemon pies, lemon cakes, candies, jams and marmalades, and also for medicinal purposes due to its high content of vitamins.

Lemon Fruits and peel were processed into various value added products like lemon Squash, lemon salt pickle, lemon sweet pickle, lemon sweet pickle without oil, lemon candied peel, lemon candied peel with chocolate, lemon candied fruit slices, lemon candied fruit slices with chocolate and lemon jelly. Lemon peel also processes into essential oil products.

Sensitivity of lemon fruits to chilling injury makes it hard to store in the commercial cold stores. So, due to sensitivity to chilling injury and limited shelf life of lemon fruit, it becomes important to process it in the form of juice to reduce the surplus in the market in its peak season of production. Preservation of fruit in the form of juices has turn out to be the business activity of great significance and countries with rich fruit resources with short harvesting season are emphasizing more for establishes storage to keep up quality of fruits, enhance shelf life and preserve fruit juices for availability in off-season. Fruit juices are preserved by various methods such as freezing, irradiation, heat processing and addition of chemical preservatives.

Food fortification is the process of adding micronutrients (essential trace elements and vitamins) to food. It can be carried out by food manufacturers, or by governments as a public health policy which aims to reduce the number of people with dietary deficiencies within a population. Food fortification has a long history of use in industrialized countries for the

Successful control of deficiencies of vitamins A and D, several B vitamins (thiamine, riboflavin and niacin), calcium, iodine and iron. In the less industrialized countries, fortification has become an increasingly attractive option in recent years, so much so that planned programmers have moved forward to the implementation phase more rapidly than previously thought possible. Interest in micronutrient malnutrition has

increased greatly over the last few years. One of the main reasons for the increased interest is the realization that micronutrient malnutrition contributes substantially to the global burden of disease. In 2000, the *World Health Report*1 identified calcium, iodine, iron, and vitamin A and zinc deficiencies as being among the world's most serious health risk factors.

Concern for the prevention of osteoporosis has led to an increase in food fortification with calcium in World. Increased awareness of the importance of calcium (Ca) for bone health throughout life has led to an increase in the number and types of Ca supplements and to Ca fortification of foods. Different calcium sources for fortification have advantages in terms of cost, calcium content, convenience, and their taste compatibility with foods. Calcium is a key mineral in the human body, necessary for normal growth and development of the skeleton as well as for teeth, nerve, muscle and enzyme functions. As the body's calcium absorption capabilities reduce with age, it is vital for the ageing to have a sufficient calcium intake. There are several options to avoid calcium deficiency by increasing the daily calcium intake.

Health benefits of Calcium:

- Essential for development, growth and maintenance of bone
- Regulate muscle contraction
- Key role in blood clotting
- Lowers blood pressure
- Improved cholesterol values
- Lower risk of colorectal adenomas, a type of non-cancerous tumour

Prevention of vitamin D deficiency and insufficiency remains an international health care priority. Rates of vitamin D deficiency and insufficiency are highest among elderly and institutionalized adults In addition, darker-pigmented persons and Asians have a higher prevalence of vitamin D insufficiency because their skin is unable to

produce vitamin D3 efficiently. Vitamin D insufficiency results in secondary hyperparathyroidism and causes rickets in children and osteomalacia and osteoporosis in adults. Increasing evidence indicates that vitamin D insufficiency is associated with an increased risk of colon cancer, breast cancer, prostate cancer, and other cancers. Vitamin D is difficult to obtain from the diet because it is not naturally present in many foods. Fortification of food with Vitamin D is increasing rapidly worldwide. Marketing demand of Calcium and vitamin D fortified fruit juices is growing.

Health benefits of Vitamin D:

- Help strengthen muscles
- Help strengthen bones
- Support immune system and fight inflammation
- Help strengthen oral health
- Help prevent type 1 and typ3 diabetes
- Help treat hypertension
- Reduce risk of certain cancer

2. Fortified Lemon juice Processing

Citrus lemon Processing

The fresh fruits have limited shelf life; therefore, it is necessary to process fresh fruits in to different value added products to increase its availability over an extended period and to stabilize the price during the glut season. The primary processing of lemon included cleaning, cutting, juice extraction and blanching. Lemons were sorted out, separated from bruised and damaged fruits, and then washed thoroughly in fresh tap water to remove the dust and extraneous material. The adhering moisture was removed by using muslin cloth. One set of cleaned Lemon were cut into two halves to remove the seeds and the juice was extracted from them. The extracted juice was stored in sterilized bottles for secondary processing. The peel of lemon, a byproduct was blanched in 5% salt solution for 20 minutes. Blanching was repeated again after 20 minutes to ensure that the bitterness in the peel is completely removed. The blanched peel was dried on a muslin cloth to remove the excess moisture (Lal, 1967). Another set of whole lemon were used to make value added products like pickles, Jelly and candied peel products. The primary processed lemon juice and peels were used to develop different products. Whole lemon was used for making pickles (sweet pickle and salt pickle); extracted juice was used in making squash, fruit extract was used for making jelly; peel of lemon and whole fruit with peel was used to make candied peel and candied fruit slices (with and without chocolate coating).

Preservation Techniques

Fresh Citrus lemons are very sensitive to post-harvest injuries/losses/spoilages, which limits storage for long periods, and in order to expand the potential markets, most of the production is processed in to value added products. Fruits juices are preserved by various methods such as freezing, irradiation, heat

processing, innovative packaging and addition of chemical preservatives, however it is well known fact that nutritional and sensory quality of juice changes during extraction, preservation treatment and storage. The shelf life of fresh lemon at room temperature is about 5-6 days and at refrigerated temperature for 3-4 weeks. Lemons tend to have a short shelf-life if not stored properly; majorly because they lose their moisture, grow unwanted black spots and start to deteriorate. The small pores in lemon's outer layer allow moisture to escape the fruit, making it dry and flavourless.

Physical treatments

The new physical treatment applications have been reported to prolong the shelf life of the fresh lemons. These treatments modifies the environmental conditions of lemon storage, effecting the fruit physiology and biochemistry and inhibiting the development of micro-organisms contaminating the fruit surface, keeping the original physico-chemical quality of the fruit.

Drying

Drying has many advantages for food quality with decreasing water activity, reducing microbiological activity and minimizing physical and chemical changes. Drying is by far the most popular and effective way of processing/preservation of lemon known from prehistoric times. Important advantages of this method are its low cost and the fact that the obtained product does not depend on refrigeration. Pre drying treatments may include blanching in boiling water (normally for 1 minute) (Blanching is a slight heat treatment, using hot water or steam that is applied mostly to fruits before canning or freezing. It is done by immersing fruits in water at a temperature of 90-95°C. The result is that fruits become soft and the enzymes are inactivated. Blanching is done before a product is dried in order to prevent unwanted colour and odour changes and an excessive loss of vitamins.) And/or sulphuring (i.e., treatment with sulphur dioxide) (In this method, sublimed sulfur is ignited and burned in an enclosed box with the fruit. The sulfur fumes penetrate the fruit and act as a pre-treatment by retarding spoilage and darkening of the fruit. The sulfur fumes also reduce the loss of vitamins A and C.). These methods, however, are not easily compatible with the traditional technique of sun

drying, but they are often practiced before solar or mechanical dehydration. The treatments accelerate dehydration, control browning of the drying fruit, and may improve its texture and reduce infestation. Blanching also helps retain color and slow oxidation. Sulphuring can achieve long-term anti-darkening and retards spoilage. Drying can be done by various methods:

Traditional Sun Drying: During sun drying, the fruits are kept on the trays, and each lemon is periodically turned from one side to the other until lemon is dried. Usually it takes 3 to 5 days, depending on the weather. The effects of ambient temperature and solar radiation on the efficacy of fruit sun drying were investigated by using mathematical modelling. The main problem of the sun drying method is the high risk of fruit infestation with pests, pathogens and dust due to its contact with soil and prolonged exposure to open environment.

Solar drying: Introduction of more sophisticated drying methods is intended to accelerate dehydration and to limit the fruit contact with the environment, thus reducing the risk of contamination. Solar dryers use the same energy source as the traditional sun drying, but the process is more energy efficient and conducted within plastic or glass covered space. The solar drying was 2.5 to 3 times faster than the traditional method; however, the sun-dried fruit received better scores in the organoleptic test.

Mechanical dehydration: The use of industrial equipment (e.g., dehydrator air flow tunnels) is another alternative to the conventional sun drying. Its advantages include better sanitation conditions, controllable and uniform technological parameters, fast process, and lower labour demand. The study showed that a 7 hour industrial dehydration gave a ready-to-market product provided a preservative potassium sorbate was applied to ensure microbiological stability. Similar quality was attained after simulated sun drying for as long as 120 hours. Extension of industrial dehydration above 11 hours gave a product not requiring chemical additives for its

preservation. However, rehydration was needed to ensure appropriate fruit palatability.

Osmotic Dehydration: Osmotic dehydration is combined with drying methods to improve food quality and reduce energy needs. Osmotic dehydration is a process that provides removing partial water from food by impregnation of hypertonic solution and it has the potential to remove water at low temperatures in addition, it is an energy efficient method, as water does not go through a phase change. Some properties of products such as colour, texture and aroma are preserved by osmotic dehydration. In addition to, osmotic dehydration extends the shelf life of products by reducing the water activity.

Infrared drying: In infrared drying, lemon is dried directly by absorption of infrared energy. It has high energy efficiency and short drying time. Infrared heating offers many advantages over conventional drying under similar drying conditions. Studies comparing infrared drying with techniques based on air convec- tion showed that the infrared radiation method is quicker than convection methods. That is suitable if processing time is a prime factor (Hebbar and Rastogi 2001; Nowak and Lewicki 2005). Since the material is heated rapidly and more uniformly, the infrared radiation energy is transferred from the heating element to the product without heating the surrounding air. The irradiated surface evaporates much more water than that of not

heated until 80% of water is removed and drying time shortened by up to 50% when heating is done with infrared energy. Infrared radiation (IR) has been applied in conjunction with several drying processes because it has advantages of in-creasing the drying efficiency.

Refrigeration

The method of freezing is an important consideration in the freezing of foods. Common freezing methods include *air-blast freezing*, where high-velocity air at about - 30° C is

blown over the food products; *contact freezing*, where packaged or unpackaged food is placed on or between cold metal plates and cooled by conduction; *immersion freezing*, where food is immersed in low temperature brine; *cryogenic freezing*, where food is placed in a medium cooled by a cryogenic fluid such as liquid nitrogen or liquid or solid carbon dioxide; and the combination of the methods above.

Vacuum packing

Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle. The vacuum environment strips bacteria of oxygen needed for survival, slowing spoiling. Vacuum-packing is commonly used for storing dried fruits to reduce loss of flavor during oxidation.

Freezing

Freezing is also one of the most commonly used processes commercially and domestically for preserving fruit including prepared fruit stuffs which would not have required freezing in their unprepared state. Lowering the temperature below the freezing point of the product stops microorganisms from growing and reduces the activity of enzymes. Fruits are heat treated (blanched) before freezing to eliminate enzymes. Home freezers are held at -10°C, commercial freezers are under -18°C. At this temperature, the growth of micro-organisms is almost stopped.

Chemical treatment: Thermal processing of citrus juice lowers the ascorbic acid content. Sulfur dioxide acts as an antimicrobial agent and also stabilizes ascorbic acid and it is added in fruit juices in the form of sulfites and metabisulfites of sodium or potassium. Research found that citrus juice with sodium benzoate without the additions of sugar could be useable up to 30 days. The action of sulphur dioxide as an antimicrobial agent as well as a stabilizer of ascorbic acid depends on the pH of the food. It is, therefore, significant to assess its effectiveness in a high acid juice such as orange and lemon juice.

Pasteurization

Pasteurization is a process of heating a product at a specific temperature for a controlled period of time to destroy the most heat resistant vegetative pathogenic organism. The process is also applied for fruit juices and juice products.

Canning

Canning involves cooking food, sealing it in sterile cans or jars and boiling the containers to kill bacteria.

MAP

Unlike most food products, fresh fruits and vegetables continue to respire after they have been harvested. This process consumes oxygen and produces carbon dioxide and water vapour. The key to keeping these packaged products fresh for as long as possible is to reduce the respiration rate without harming the quality of the product – its taste, texture and appearance. In general, the rate of respiration can be reduced by keeping the temperature low, having lower levels of oxygen in the packaging atmosphere and increased levels of carbon dioxide.

Modified atmosphere packaging known as MAP technology and controlled atmosphere storage (CAS) are novel techniques that are widely applied for preservation of agricultural products especially for fruits and vegetables. These techniques are used to supplement low temperature management to delay ripening, reduce physiological disorders, and suppress decay in many fresh fruit and vegetable MAP is defined as 'the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air whereas controlled atmosphere storage (CAS) involves maintaining a fixed concentration of gases surrounding the product by careful monitoring and addition of gases, the gaseous composition of fresh MAP foods is constantly changing due to chemical reactions and microbial activity. Gas exchange between the pack headspace and the external environment may also occur as a result of permeation across the package material.

Artes and Tomas Barberan reported the applications of controlled and modified atmospheres (CO_2 enriched and/or reduced O_2), use of the thermal treatments for fruit conditioning and curing and intermittent warming during the cold storage to avoid fungal developments and physiological disorders that develops below 5°C. Active MAP involves a quick process of gas flushing or gas replacement or the use of gas-scavenging agents to establish a desired gas mixture within the package. Studies have shown that modified atmosphere packaging (MAP) and controlled atmosphere storage (CAS) have the ability to delay quality loses and thus extends the shelf life of fresh or minimally processed or fresh-cut produce Modified atmosphere packaging can result in reduction in the respiratory activity by decreasing O_2 concentration, delay in softening and ripening and a reduced incidence of the various physiological disorders and pathogenic infestations. MAP sensing and Monitoring: 'Smart' or 'active' or 'intelligent' packaging system is introduced to improve the safety of MAP products and to extend the technology to a broader spectrum of products. Summers defined the Smart packaging as an interaction between the packing system and the product itself which confers intelligence appropriate to function and use of the product with the ability to sense or to be sensed and to communicate. Nano biosensors can serve as the best smart packaging tool for MAP sensing and monitoring. Research recommended a controlled

atmosphere of 5% O_2 + 0-5% CO_2 composition for the storage of Lemon at 5° C with RH 95% to minimize decay weight loss and chilling injuries and better keeping quality.

The advantages of MAP are extending the shelf-life, preserving or stabilizing the desired properties of fruits and vegetables, convenience in use and distribution for retail sale. Recent development achieved in packaging material such as bio-based polymers provides feasibility of MAP development for new applications. Also developments in MAP claim new equipment and machinery and accurate control of process. Recent advances in mechatronics and automation provides reliable control of all machine functions in MAP process such as temperature and gas injection. Many factors should be considered to facilitate MAP process based on the nature of the

product and the market requirements. Some of these parameters are quality, clean ability, throughput, flexibility, operating cost, processing yield and equipment price.

3. Preparation of Fortified Lemon juice

Flow Diagram

The typical Procedure for manufacturing of Fortified lemon juice is as below:

Lemon fruits

(Mature and ripened fruits with characteristic flavor will be used)

↓

Sorting

↓

*Washing and cleaning (Soaked in water containing chlorine solution (10-20ppm) for 2-5 minutes)

↓

Juice extraction

↓

Juice Clarification

↓

Preservatives addition (Potassium metabisulphate at rate of 0.1 % or sodium benzoate at rate of 0.1%)

↓

Filtration (Filtration by UF membrane of MW cut-off 300kDa)

↓

Homogenization (Optional)

↓

*Heat treatment (77°C for 30 seconds)

↓

Fortification with Calcium and Vitamin D

(0.16 % Tricalcium citrate & Vitamin D 4.17 mg/liter)

↓

Filling and packaging

↓

*Storage

*Established Critical Control point

Receiving of lemon fruits: Fruit goes through inspection lines for removal of bruised or damages fruits.

Washing and cleaning: The fruits are graded and soaked in water containing chlorine solution (10-20ppm) for 2-5 minutes, scrubbed by revolving brushes, rinsed with clean water, and inspected again to remove the damaged ones.

Juice extractor: Juice is extracted by automatic juice extractors. These extractors produces juice free of peel extractives.

Filtration: Juice is screened as soon as possible to remove insoluble solids, which contain leachable substances that may impair flavor, color and cloud stability of juice. For better juice yields, screening in paddle finishers or screw presses id done to remove coarse pulp. UF unit for clarification of lemon juice is also used. Membrane with a molecular weight cut-off of 300kDa was best suited for clarification of lemon juice.

Preservatives addition: Preservatives are added to prevent or reduce the microbial spoilage. Sulfur dioxide acts as an antimicrobial agent and also stabilize ascorbic acid and it is added in fruit juices in the form of sulfites and metabisulpfites of sodium and potassium. Potassium metabisulphate at rate of 0.1 % is added or sodium benzoate at rate of 0.1% is also added.

Pasteurization: Heat the juice to a temperature for sufficient time and to assure practical sterility as well as cloud stability by inactivating natural juice enzymes. Temperature of 77°C for 30 seconds is used. The juice is cooled immediately after pasteurization by passing through the heat exchanger.

Packaging: Different types of packaging including cans, bottles, cartons, drums and barrels made up of glass, metals, plastic, or laminates are used for the packaging of Lemon juice.

Equipment Employed

Sorting Conveyor **Washing tank**

Fruit Juice Extractor

Filter press

Inline Homogenizer

Steam kettle

Juice storage tank (Insulated)

Bottling line

Food safety concern:

Common Food Safety concern should be considered while handling and processing of products are mentioned below:

1. Bacterial and Pathogen Contamination:

- Chlorine dioxide solution (10 ppm) with contact time of 2-5 minutes to sanitize surface of fruits. And it destroys microorganisms including pathogen.
- Hot filling is necessary for achievement of desired shelf life.
- Irradiation: A treatment with ionizing radiation at doses up to 1 KGy can be applied to fruit and vegetables. It is generally applied to inhibit post-harvest pathogens and to protect produce quality. Irradiation may be effective for eliminating pathogenic microorganisms from surfaces of produce. An irradiation dose of 1 KGy has been reported to be effective for destruction of Listeria monocytogenus.
- Storage area should have accurate recorded temperature and humidity control to prevent or delay microbial growth.
- Keeping and maintain low temperature during transportation also can inhibit or greatly retard growth of pathogens.

2. Fungal and Mold Contamination:

- Damaged, decayed, rotten and over ripen fruits removal is essential for preventing and reducing contamination.
- Preservatives like Sulphur dioxide, Potassium metabisulphate and other suitable preservatives are added in prescribed limit to prevent and reduce the contamination of Fungal and Mold.
- Maintain proper hygienic conditions at every possible steps.

3. Pesticides/fertilizer residues:

- Ultrasonic washing will eliminate all the fertilizers and pesticides residues used during farming and present in fruit.

Other Risk associated with Lemon as follow:

1. Lemons have high acid content, so their juice may affect people with Mouth ulcers; if overconsumed.

2. Gastro esophageal reflux disease (GERD): Over consumption of lemon juice can worsen symptoms, such as heartburn and regurgitation.

3. Lemons are quite acidic, so eating them frequently may be harmful to dental health if your tooth enamel becomes damaged

4. Allergies: Citrus fruit may cause allergic reactions. It may also cause contact allergy and skin irritation in people with dermatitis.

4. Packaging of Fortified lemon juice

Packaging Material Employed for Such Products

Glass:

Chemically inert and will not affect the quality, odour or taste of the product. It is Strong, rigid and 100% recyclable.

PET (Poly Ethylene terephthalate)

It is Light weight, flexible and recyclable. It is considered to be the backbone of packaging films. Polyethylene films are fairly free of plasticizers and other additives and are quite extensively used as a part of lamination. Its ability to heat seal increases its value.

Low Density Polyethylene (LDPE) is an economical material with low WVTR, however, it has high permeabilities to flavours/volatiles, poor grease resistance and are limp. High-density polyethylene (HDPE) is stiffer, more translucent and has better barrier properties but needs higher temperature for sealing.

Later additions include high molecular weight high-density polyethylene (HM HDPE) and linear low-density polyethylene (LLDPE). HM HDPE is a paper like film with high physical strength and barrier properties, but is less transparent than ordinary polyethylenes. HM HDPE is available in twist-wrap grades. Polyethylene films are also suitable for making bags and pouches. A copolymer of polyethylene and poly vinyl alcohol, and EVOH has outstanding gas barrier properties especially when dry.

Polypropylene

Polypropylene films are undergoing a growth trend in the food industry. They have better clarity than polyethylene and enjoy superior machinability due to stiffness. Lack of good seal ability has been a problem, however, PVDC and vinyl coating have been used to overcome this problem. Some varieties of PP have been specially developed for twist-wrap applications as they have the ability to lock in position after

twisting. Pearlised polypropylene with an opal finish and attractive gloss is also used. Both as Laminates and overwraps, PP film is now widely used for all types of foods packaging applications. Trays can be ordered in bulk in multiple sizes, or they can be custom molded to your products. These are the plastic trays you find inside deluxe two-piece boxes or gift boxes that hold products in place.

Mainly aluminium and steel metal cans are also used for such premium products. The Lemons packed in Primary and Secondary packages are finally packed into cartons.

The modified atmosphere packaging offered an additional innovative tool for the optimal use and value addition of lower grade lemon fruits.

Tetra Packaging

Tetra packaging is six layer packaging technology. It uses Aseptic packaging technology. In aseptic processing the product and the package are sterilized separately and then combined and sealed in a sterile atmosphere. It consists six –layers material as follows:

i. First layer- which seals in the liquid

ii. Second layer is adhesion layer of polyethylene

ii. Third layer is aluminium foils, which acts as barrier for oxygen, flavour and light.

iv. Fourth layer is adhesion layer again of polyethylene same as second.

v. Fifth layer is of paper board for stability.

vi. Top layer is again of polyethylene for protection against outside moisture.

Aseptic Packages

- Aseptic packages are made by combining thermoplastic with paperboard and aluminium foil.
- Aluminium foil layer is strong barrier for O_2 and light.
- Inner plastic layer is made of polyethylene makes it possible to seal through the liquid.
- The outer paper layer provides the stiffness thus, enabling maximum utilization of available storage and transportation space. Excellent graphics are possible leading to good display and shelf appeal.

5. Food Safety regulations and Standards

Standards for lemon juice which are as under:

FOOD SAFETY AND STANDARDS (FOOD PRODUCTS STANDARDS AND FOOD ADDITIVES) REGULATIONS, 2011 (2.3 Fruit and Vegetable Products)

2.3.6 Thermally Processed Fruit Juices:-

Thermally Processed Fruits Juices (Canned, Bottled, Flexible and/ or Aseptically Packed) means unfermented but fermentable product, pulpy, turbid or clear, intended for direct consumption obtained by a mechanical process from sound, ripe fruit or the flesh thereof and processed by heat, in an appropriate manner, before or after being sealed in a container, so as to prevent spoilage. The juice may have been concentrated and later reconstituted with water suitable for the purpose of maintaining the essential composition and quality factors of the juice. It may contain salt. One or more of the nutritive sweeteners may be added in amounts not exceeding 50 g/kg but not exceeding 200g/kg in very acidic fruits except in case of Apple Juice, Orange Juice (reconstituted from concentrate), Grape Juice, Pineapple Juice (reconstituted from concentrate). The product is not required to be called sweetened juice till the added nutritive sweeteners are not in excess of 15g/kg

The product shall meet the following requirements:-

Food article	TSS min (%)	Acidity expressed as Citric Acid max (%)	Added Nutritive Sweeteners max (ppm)
Lemon juice	6	4.0	200
Lime juice	-	5.0	200

List of Food Additives for use in Juice under food safety and standards (food products standards and food additives) regulations, 2011 (Table: 9):-

Sl No	Name of additives	Products	Limits
1	Citric Acid	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP
2	Lactic Acid	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP
3	Malic Acid	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP
4	Ascorbic Acid	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP

Sl No	Name of additives	Products	Limits
1	Natural Flavouring and natural flavouring substances	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP
2	Natural Flavoring identical substances	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	GMP
3	Benzoic Acid	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	600 ppm max
4	Sulphur di-oxide	Fruit /vegetable Juice, Pulp, Puree, with preservatives for industrial use only	1000 ppm max

List of Microbiological standard for Juice under food safety and standards (food products standards and food additives) regulations, 2011 (Table: 4):-

Sr No	Products	Parameters	Limits
1	Thermally processed fruits and vegetable products	a) Total plate count	a) Not more than 50 / ml

		b) Incubation at 37°C for 10 days and 55°C for 7 days	**b) No changes in pH**
2	**Other fruits and vegetables products covered under Regulation 2.3**	**Yeast and mould count**	**Positive in not more than 100 count/gm**

List of standards for contaminants for Juice under food safety and standards (Contaminants, Toxic and Residues) regulations, 2.1 metal contaminants:-

Sr No	Article of food	Name of the Metal Contaminants	Parts Per Million Metal by Weight
1	Beverages (Juices of orange, grape, apple, tomato, pineapple and lemon)	Arsenic	0.2
2	Tomato puree, paste, powder, juices and cocktails	Copper	5.0
3	Juice of orange, grape, apple, tomato and lemon	Arsenic	0.2
4	Juice of orange, grape, apple, tomato and lemon	Tin	250
5	Juice of orange, grape, apple, tomato and lemon	Zinc	5.0

6. SANITARY AND HYGIENIC REQUIREMENTS FOR FOOD MANUFACTURER/ PROCESSOR/HANDLER

- The place where food is manufactured, processed or handled shall comply with the following requirements:
- The premises shall be located in a sanitary place and free from filthy surroundings and shall maintain overall hygienic environment. All new units shall set up away from environmentally polluted areas.
- The premises to conduct food business for manufacturing should have adequate space for manufacturing and storage to maintain overall hygienic environment.

- The premises shall be clean, adequately lighted and ventilated and sufficient free space for movement.
- Floors, Ceilings and walls must be maintained in a sound condition. They should be smooth and easy to clean with no flaking paint or plaster.
- The floor and skirted walls shall be washed as per requirement with an effective disinfectant the premises shall be kept free from all insects.
- No spraying shall be done during the conduct of business, but instead fly swats/ flaps should be used to kill spray flies getting into the premises.
- Windows, doors and other openings shall be fitted with net or screen, as appropriate to make the premise insect free.
- The water used in the manufacturing shall be potable and if required chemical and bacteriological examination of the water shall be done at regular intervals at any recognized laboratory.
- Continuous supply of potable water shall be ensured in the premises. In case of intermittent water supply, adequate storage arrangement for water used in food or washing shall be made.
- Equipment and machinery when employed shall be of such design which will permit easy cleaning. Arrangements for cleaning of containers, tables, working parts of machinery, etc. shall be provided.

- No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of food. (Copper or brass vessels shall have proper lining).
- All equipment's shall be kept clean, washed, dried and stacked at the close of business to ensure freedom from growth of mould/ fungi and infestation.
- All equipment's shall be placed well away from the walls to allow proper inspection.
- There should be efficient drainage system and there shall be adequate provisions for disposal of refuse.

- The workers working in processing and preparation shall use clean aprons, hand gloves, and head wears.
- Persons suffering from infectious diseases shall not be permitted to work. Any cuts or wounds shall remain covered at all time and the person should not be allowed to come in direct contact with food.
- All food handlers shall keep their finger nails trimmed, clean and wash their hands with soap, or detergent and water before commencing work and every time after using toilet. Scratching of body parts, hair shall be avoided during food handling processes.
- All food handlers should avoid wearing, false nails or other items or loose jewellery that might fall into food and also avoid touching their face or hair.
- Eating, chewing, smoking, spitting and nose blowing shall be prohibited within the premises especially while handling food.
- All articles that are stored or are intended for sale shall be fit for consumption and have proper cover to avoid contamination.
- The vehicles used to transport foods must be maintained in good repair and kept clean.
- Foods while in transport in packaged form or in containers shall maintain the required temperature.

- Insecticides / disinfectants shall be kept and stored separately and away from food manufacturing / storing/ handling areas.

7. Labelling Standards

Labelling requirements for packaged food products as laid down in the Part VII of the Prevention of Food Adulteration (PFA) Rules, 1955, and the Standards of Weights and Measures (Packaged Commodities) Rules of 1977, require that the labels contain the following information:

1. Name, trade name or description

2. Name of ingredients used in the product in descending order of their composition by weight or volume
3. Name and complete address of manufacturer/packer, importer, country of origin of the imported food (if the food article is manufactured outside India, but packed in India)
4. Nutritional Information
5. Information Relating to Food Additives, Colours and Flavours
6. Instructions for Use
7. Veg or Non-Veg Symbol
8. Net weight, number or volume of contents
9. Distinctive batch, lot or code number
10. Month and year of manufacture and packaging
11. Month and year by which the product is best consumed
12. Maximum retail price

Wherever applicable, the product label also must contain the following

The purpose of irradiation and license number in case of irradiated food. Extraneous addition of colouring material. Non-vegetarian food – any food which contains whole or part of any animal including birds, fresh water or marine animals, eggs or product of any animal origin as an ingredient, not including milk or milk products – must have a symbol of a brown colour-filled circle inside a brown square outline

Prominently displayed on the package, contrasting against the background on the display label in close proximity to the name or brand name of the food.

Vegetarian food must have a similar symbol of green colour-filled circle inside a square with a green outline prominently displayed.

All declarations may be: Printed in English or Hindi on a label securely affixed to the package, or Made on an additional wrapper containing the imported package, or Printed on the package itself, or May be made on a card or tape affixed firmly to the package and bearing the required information prior to customs clearance.

Exporters should review the Chapter 2 of the "FSS (Packaging and Labeling) Regulation 2011" and the Compendium of Food Safety and Standards (Packaging and Labeling) Regulation before designing labels for products to be exported to India. FSSAI revised the labeling Regulation and a draft notification to that effect was published on April 11, 2018, inviting comments from WTO member countries and the comments received are under review and the publication date remains unknown.

According to the FSS Packaging and Labeling Regulation 2011, "prepackaged" or "pre packed food" including multi-piece packages, should carry mandatory information on the label.

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