Impact of Chemical, Thermal and Non-Thermal Techniques on Guava Based Functional Beverages

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Abstract:
Guava fruit is rich in vitamin c and other vitamins are also present like vit A and vit B (thiamin and niacin) and significant amounts of phosphorus, iron and calcium that's why guava is widely used as functional beverage by making blends with other fruits and vegetables and drinks. Guava based functional beverages helps in prevention from many cardiovascular diseases. in this study different types of guava-based beverages and impact of chemical; thermal and non-thermal techniques are studied on guava abased beverages. Chemical treatment is applied while using sodium benzoate, sodium metabisulphite and a combination of both preservatives which gives best result during storage. Effect of different time temperature treatments are applied on guava beverages and different quality characteristics of beverages are studied including organoleptic characteristics and physicochemical characteristics. To prevent from quality losses different non thermal techniques and electro thermal treatment i.e., Ohmic

heating are applied effects are also studied like sonication, ozonation and especially cold plasma technology and different analysis are observed like microbial and ph. analysis etc.

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1. Introduction

The European Commission defines functional food as "a food product that can only be considered functional if, in addition to the basic nutritional effect, it has a positive effect on one or more functions of the human organism and thus improves general physical condition and/or. “Reducing the possibility of illness development. Beverages are the most popular type of functional food on the market; in fact, they easily suit consumer criteria for size, shape, storage, and the ability to absorb desired nutrients and bioactive substances. (Kasapoğlu et al., 2019)Product or web differentiation is essential for effective functional food creation. Packaging design allows for product differentiation. (2019, Sahar et al.) Semiotics is the greatest way for identifying distinctive product package design for functional beverages. This method is used to investigate or analyze information-carrying signals (Sahar et al., 2019). The functional beverage industry has experienced a surge in the number of products with differentiating qualities such as boosting gut or cardiovascular health, supporting the immune system, assisting in weight management, or countering ageing processes over the previous several decades.Nowadays, scientific data supports the idea that diet can meet nutritional needs and have a role in a variety of illnesses (Corbo et al., 2014). Because of their health benefits and the possibility that they will match consumer desires for nutritional content, practical pack volume, pack size, design, and packaging, beverages are currently the most important active functional foods. Appearance, transportation and storage convenience, and storage stability. Beverages are an excellent source of nutrients, bioactive components, antioxidants, vitamins, minerals, fatty acids, plant extracts, probiotics, prebiotics, micronutrients, and other beneficial substances. Functional beverages derived from natural ingredients with specialized physiological qualities are at the heart of food industry innovation. Functional foods have numerous health benefits. Many isolated nutrients, such as dietary supplements, herbal items, and fortified diets, are found in soups, cereals, fortified juices, or juices. Functional drinks are intended to relieve thirst, maintain healthy fluid and hydration levels, and provide nourishment. Orange juice fortified with vitamin C, calcium, and phytosterols, green tea supplemented with epigallocatechin gallate, and berry drinks fortified with anthocyanins are other examples. (Maia et al., 2019) Proper labelling information for functional beverages is necessary for the consumer's benefit. Functional beverages are the fastest expanding sub-sector of functional foods and non-alcoholic beverages. According to statistics, the development in the last two years is related to the maturity of the soft drinks market, and many large multinational corporations have invested in the functional drinks field globally. As a result, the per capita figure has increased while the growth of carbonated beverages has halted. Beverages are still on-the-go items, so in addition to performance, the customer also receives hydration and is a critical component in the prevention of a specific disease (Ghoshal & Kansal, 2019). Fruits are nutritious because they are high in minerals, vitamins, and other nutrients. Fruit juices are not often consumed in India, and the fruit juice sector is still in its infancy. Fruit drinks are becoming increasingly popular due to its pleasant taste, taste, and nutritious characteristics. The drinks are getting increasingly popular all around the world. In general, each fruit has its unique intrinsic features that set it apart from others.Its original features, such as a very sour, astringent, mild, and pungent flavor, as well as other variables, limit its employment in the creation of fruit goods. As a practical alternative to obtaining high-quality fruit drinks with added value, mixtures of two or more fruit juices and their beverages with the addition of fruit juices or spice extracts are therefore eliminated as healthy drinks. Both in terms of sensory and nutritional value. The taste, aroma, flavor, and nutrition of two or more fruits can be improved by combining them with appropriate spices. Finally, the new product can be created by combining appropriate fruit juices and spice extracts in the proper proportions to obtain high sensory acceptance. The physico-chemical organoleptic properties can change during the processing & storage conditions due to the influence of oxidation, temperature and light (Subramani, 2018).

Guava (Psidium gujava) is a popular tropical and subtropical fruit. It is a member of the Myrtaceae family. Guava fruit is sweet and juicy, with red or yellow flesh pulp and many seeds inside. Fresh fruit includes around 80% moisture, 20% dry matter, 0.7% fat, 1% ash, and 1.5% protein. Guava is unusually high in ascorbic acid (vit C), and it also contains vitamin A (beta-carotene), vitamin B1 thiamin, vitamin B2 riboflavin, niacin, and pantothenic acid. It also contains a significant quantity of phosphorus, calcium, iron, potassium, and sodium. Guava's dietary value rises due to its high concentration of antioxidant pigments such as carotene and polyphenols (Kr Chauhan, 2014). Several research on the anti-oxidative, anticarcinogenic, and anti atherogenic properties of the primary bioactive constituents in guava and guava juice, particularly vitamin C and lycopene, have been undertaken (Sato et al., 2010). Epidemiological studies have shown that a high lycopene diet may protect against CVD and lower the risk of a number of cancers, including prostate, breast, lung, and digestive system cancer (Omoni and Aluko, 2005). Lycopene, a carotenoids pigment, is responsible for the pink flesh guava fruit's appealing color. The concentration of lycopene in the fruit flesh, as well as the concentration of color and lycopene in the fruit juice, determine the strength of the fruit's hue (Aishah et al., 2016).

This review focuses on the preparation, storage, and quality aspects of guava-based functional beverages, as well as the impact of chemical, thermal, and non-thermal processing conditions.

2. Types of beverages

Non-alcoholic or non-alcoholic beverages include straight or straight juices, sweetened juice, ready-to-serve, nectar, pumpkin, crushed, syrup, liqueur, barley water, carbonated drinks, fruit juice concentrate, and fruit juice powder; and alcoholic and fermented beverages include wine and cider, among other things. Firm, ripe fruit with a high pulp content and minimal dietary fibre, great taste, flavor, and color of the pulp, and a high total soluble solids content with low acidity for beverages are required.

2.1. Dairy based beverages

Dairy beverages are popular around the world because of the highly recommended elements included in milk, such as calcium and magnesium. Dairy drink consumption is safe and unrelated to body weight and muscle-to-fat ratio in individuals (Sahar et al., 2019). Physiologically beneficial peptides, oligosaccharides, enzymes, vitamins, and minerals are present in milk-based beverages in addition to the essential components. These substances can be used as functional constituents in the manufacturing of functional and nutritional food items with health benefits. (Mudgil & Barak, 2019).

2.2. Sports and performance drinks

Sports drinks are a core need of athletes. The overall interest for sports drinks is massive; the U.S. only market is assessed at being worth more than $1.5 billion per year. In spite of the fact that there are numerous items accessible to the purchaser, there is by and large little contrast in the composition of various economically accessible games drinks (Shraddha RC & Nalawade T, 2015). These drinks have been made for people engaged with active work and these drinks are broadly utilized by everyone in inclination to carbonated drinks. Electrolyte balancing, carbohydrates or protein loaded sports drinks are in demand nowadays (Nazir et al., 2019).

2.3. Fruit Fortified drinks

Fruit drinks are non-alcoholic beverages made by subjecting various types of fruit to a series of stringent processes to prevent food fraud or the selling of counterfeit goods. Fruit juices and beverages include, among other things, naturally extracted juices, RTS drinks, nectars, squashes, cordials, and appetizers. Many synthetic and aerated beverages are significantly more refreshing, thirst-quenching, appetizing, and nutritionally superior to these beverages (R. R. Sharma, 2019).

2.4. Guava based beverages

Guava (Psidium guajava) is a fruit that is abundant in nutrients, including vitamin C, vitamin A, vitamin B (thiamine and niacin), as well as phosphorus, iron, and calcium. It also stands out for its scent and flavor, as well as the fibre, which provides the fruit remarkable digestibility and quality (De Albuquerque et al., 2014). Drinks made from white-fleshed guava taste very good but do not have an attractive color, while pink or red-fleshed guava drinks also have an attractive color.The color of such a guava is due to a class of natural organic pigments called carotenoids. The main limitation of the pink or red-fleshed guava is its smaller plantation area, which is insufficient to meet the demand of the guava beverage industry. (Chang et al., 2020).

2.4.1. Guava whey beverages

A whey drink can restore many of the lost organic molecules and extracellular fluid organic components. Because whey digests so quickly, it is an excellent metabolic substrate. These beverages are light and refreshing, although lower in acidity than fruit juices. Guava is sometimes referred to as a "superfruit" due to its high vitamin C and A content. The seeds are high in polyunsaturated fatty acids omega-3 and omega-6, as well as fibre, riboflavin, protein, and mineral salts. Because of its high quantities of vitamin C (ascorbic acid), guava is a powerhouse in the fight against free radicals and oxidation, the primary foes that cause many degenerative diseases.The antioxidant qualities of guava are suggested to help reduce the risk of stomach, esophagus, laryngeal, oral cavity, and pancreatic cancer. Guava's vitamin C promotes vitamin E absorption, which reduces oxidation of LDL cholesterol (bad cholesterol) and increases HDL cholesterol (good cholesterol). Guava's fibre content promotes digestion and eases bowel movements. Guava's high vitamin A content is crucial for maintaining the quality and health of eyesight, skin, teeth, bones, and mucous membranes (Dattatreya et al., 2012). Guava is widely employed in indigenous healing practices around the world. Guava extract is typically composed of instillations, decoctions, tinctures, and so on. To improve the quality of guava as a nutritional supplement, a unified food web is required. To compensate for the limited shelf life of guava, research has concentrated on the development of several formulations that include guava's functional and nutraceutical characteristics for strengthening, such as: Shakes and other low-calorie beverages and fats (Chauhan et al. 2015).

2.4.1.1. Preparation of whey

Standardized milk is primarily used to generate high-quality whey. Milk is heated to 80°C and coagulated by adding a 2% citric acid solution followed by continuous stirring, resulting in complete casein coagulation. Whey is filtered through muslin fabric and preserved for subsequent use.

2.4.1.2. Preparation of guava juice

Guava fruits are washed before being sliced into slices, mixed with a mixer, then filtered through a cheese cloth. The blended pulp was then heated at 90°C for 3 minutes in a stainless-steel container to inactivate pectin enzymes before being swiftly cooled to 20°C and poured into polyethylene bags. The fruit juices were kept at -18°C until they were used.

2.4.1.3. Preparation of guava/whey beverage

Whey and homogenized guava pulp are used for preparing different blends at different mixing ratios. 0.2% carboxymethyl cellulose, 0.2% citric acid and 0.1% sodium sorbate. Resulted juice blend samples are adjusted to 18% of total soluble solids using sucrose. The beverages are filled in glass bottles, tightly closed and pasteurized at 85 degrees Celsius for 20 minutes. Such beverages then cooled and stored for 3 months at room temperature (Moussa & Manal, 2019).

2.4.2. Guava -aonla blended beverage

Guava and aonla pulp are combined to create a ready-to-serve beverage with 10% pulp, 0.22% titratable acidity, and 12–14°B TSS. The prepared beverage is heated to 78°C, chilled, and then put into 200 ml pre-sterilized glass bottles. In order to be used later, these bottles were crown-corked, pasteurized in boiling water for 20 minutes, and then stored at 18 to 35°C (Mall & Tandon, 2007).

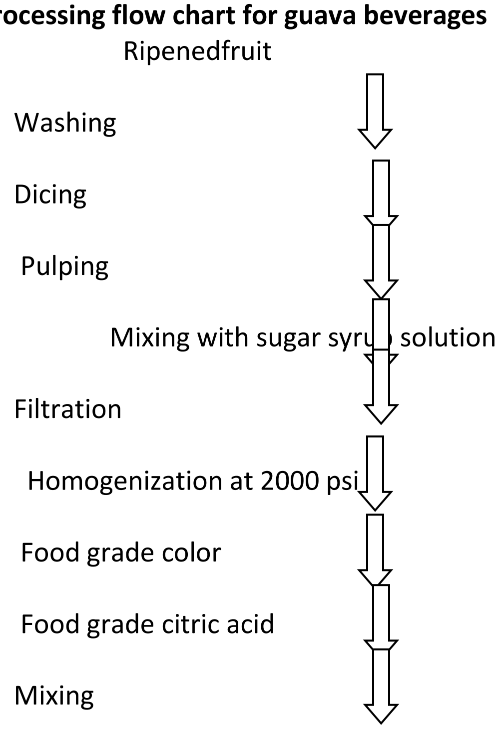
2.4.3. Yoghurt drink supplemented with guava pulp:

One of the most widely consumed dairy products worldwide is yoghurt (Saint-Eve et al., 2006). Foods that are "functional" have been popular, and their qualities have been researched with the addition of "functional" elements such fruit pulp and the addition of various fruit juices to yoghurt. Fruit juices were used to make yoghurt, producing a tastier end product. There is mounting evidence that eating more fruits and vegetables may help prevent several chronic illnesses, including cancer, heart and cerebrovascular disease, eye and neurological disorders, and cancer. (Block et al., 1992).

2.4.5. Guava jamun blend

Drink made with 60% guava pulp and 40% jamun pulp along with 15% fruit component and 15-degree brix was one of the various combinations tested. The TSS is chosen for the guava jamun mix drink because it is best judged by panelists in terms of color, body, flavor, and overall acceptability score. It has 14.06% total sugar and 0.30% titratable acidity. Total phenolics and antioxidants are reported in such blended drinks instead of these increased ascorbic acids. The traditional healers have long utilized guava (Psidium guajava L.) and jamun (Syzygium cumini L.), which are said to contain numerous bioactive components, to cure diabetes (S. Sharma, 2019).

2.5. General processing flow chart for guava beverages



Pasteurization at 80°C for 10 -20 minutes

Bottling (pre cleaned rinsed bottles using hot water and steam)

Crown corking

Cooling and storage (Thanjavur Indian Institute of Food Processing Technology, 2000)

2.6. Vitamin C stability in guava-based beverages/juices under different storage conditions using different levels of sodium benzoate and metabisulphite

Vitamin C is the most significant nutrient in guava fruit, and its stability is critical to ensure its availability. Sodium benzoate, sodium metabisulphite, and their combined effects at 0.04% and 0.005% were used to compare the stability of vitamin C at various temperatures, including room temperature (22.4°C), chilling temperature (-1.2°C), and freezing temperature (-17.3°C).

Table 2.1 Vitamin C degradation of guava juice under different storage conditions for 2 months' period

Storage conditions	Treatment	Week 0	Week 2	Week 4	Week 6	Week 8
Freezing	Control	52.4±0.50	37.3±0.46	34.2±0.26	33.0±0.20	31.2±0.26
	0.05%SB	52.4±0.50	41.5±0.53	33.5±0.87	32.5±0.36	31.3±0.36
	0.005%SMB	52.4±0.50	42.4±0.40	34.4±0.53	32.5±0.56	31.3±0.36
	0.04%SB+0.005%SMB	52.4±0.50	43.9±0.20	36.6±0.26	33.8±0.36	32.4±0.46
Chilling	Control	52.4±0.50	28.3±0.44	23.7±0.20	20.0±0.10	10.7±0.71
	0.05% SB	52.4±0.50	37.7±0.36	25.7±0.26	23.7±0.20	16.0±0.36
	0.005% SMB	52.4±0.50	32.0±0.36	29.6±0.36	25.1±0.40	18.0±0.26
	0.04%SB+0.005%SMB	52.4±0.50	37.9±0.17	30.3±0.36	26.1±0.36	19.3±0.35
Room	Control	52.4±0.50	24.6±0.44	14.7±0.10	11.5±0.56	6.8±0.26
	0.05%SB	52.4±0.50	29.8±0.36	17.1±0.20	11.9±0.10	6.9±0.30
	0.005%SMB	52.4±0.50	30.6±0.26	15.3±0.17	10.1±0.20	4.4±0.36
	0.04%SB+0.005%SMB	52.4±0.50	32.9±0.26	21.4±0.56	12.5±0.36	7.1±0.46

See table for results on the stability of ascorbic acid in guava drinks/juices, as shown by the degree of deterioration under different storage conditions at varied sodium benzoate and sodium meta-bisulfite concentrations.The results show that ascorbic acid is highly preserved under frozen storage conditions but less so under bulk storage conditions. These results are consistent with reports by Ribero et al. (2011) who observed that the degradation of vitamin C in the formulation could be caused by other restricting factors such as temperature during storage, the presence of oxygen, and the presence of trace elements. Many factors, including temperature, have been attributed to vitamin C losses in fruit juices. Steskova et al. (2006) observed that temperature, vitamin type, and matrix all influence the preservation of ascorbic acid in drinks and food, with lower storage temperatures leading to greater ascorbic acid retention. The findings show that vitamin C losses are greater at week 8 of storage, regardless of the storage conditions, the amount, and the type of preservatives used. These findings are supported by Hussain et al. (2011), who found that variables like the ascorbic acid content of mixed apple and apricot juice preserved with sodium benzoate decrease over time during the three-month storage period. The findings show that vitamin C losses are greater at week 8 of storage, regardless of the storage conditions, the amount, and the type of preservatives used. These findings are supported by Hussain et al. (2011), who found that variables like the ascorbic acid content of mixed apple and apricot juice preserved with sodium benzoate decrease over time during the three-month storage period. The results of this study are consistent with those of Ndabikunze et al. (2010) who found that the use of sodium benzoate and sodium metabisulfite at 175 ppm each increased the shelf life of juices to 90 days at room temperature (25-32 °C). It is interesting to note that while some of the preservatives used in this study are below 50% of the maximum acceptable levels (1000 mg/kg) in some cases, they can stabilize vitamin C. The findings also show that stabilizing ascorbic acid in guava juice with sodium benzoate and metabisulfite at concentrations of 0.04% and 0.005%, respectively, is more effective than utilizing the two preservatives separately at concentrations of 0.05 and 0.005%. in the dining room (K & K, 2013).

Table 2.2 Average loss (%) of vitamin C (mg/100 mL) at different storage conditions (°C) at the end of the 02 months' storage period using different levels of preservatives.

Storage condition	**Type of juice**	**Control**	**0.05%SB**	**0.005%SMB**	**0.04%SB+0.005%SMB**
Freezing (-17.4°C±0.3)	Guava	40.5	40.3	40.3	38.2
Chilling (-1.2°C±0.1)	Guava	79.6	69.5	65.6	63.2
Room (22.4°C±1.3)	Guava	87.1	86.8	86.6	86.3

2.7. Effect of artificial and natural sweeteners on biochemical composition and organoleptic evaluation of guava ready to serve beverage during storage

Artificial sweeteners aid in reducing the risk of dental decay and other health issues brought on by consuming caloric sweeteners like sucrose in excess (Cardello and Damasio, 1997). If consumers follow an energy-restricted diet and consume nutrient-dense meals, the use of low-calorie sweeteners may improve dietary quality (ADA, 2004). Guava pulp is extracted using a pulper machine and strained using a 1mm stainless steel filter. The finished product is cooked at 85°C for 30 minutes, with the acidity remaining at 0.3%. The produced RTS is filled into clean and sterilized glass bottles with a capacity of 200ml, pasteurised in boiling water for 30 minutes, chilled, and stored at room temperature. The processed product is monitored for biochemical and organoleptic evaluation up to 90 days with 30 day intervals.

The therapy is repeated three times in a completely randomized block design.

2.8. Impact of thermal treatment on guava-based beverages:

Guava whey blended beverage was given a time-temperature treatment for determining the desirable characteristics related to its nutritional parameters and shelf life. Different pasteurization temperatures are given to the guava whey beverage like 60°C for 15 minutes, 65°C for 25 minutes and 70°C for 35 minutes. The sample is analyzed regularly at 15 days' interval like 0, 15, 30, 45, 60, 75 and 90 days as shown in table (Bhat et al., 2018).

Protein content varied from 0.306 to 0.293 in the guava-based whey beverage and 0.318 to 0.303 in the controlled whey beverage, respectively. As a result, the protein amount of the blended beverage was unaffected by temperature or timing. Lactose concentration in controlled and blended beverages varied from 5.24 to 3.42 and 5.23 to 4.88, respectively. Lactose, which is found in higher concentrations in cheese whey, is removed during the paneer-making process. The Acidity of guava-whey beverage slightly increased and varied from 1.37 to 1.46 in controlled and i.31 to 1.42 in experimental/ blended beverage. The pH of beverage varied from 4.10 to 3.83 in controlled and 3.93 to 3.84 in blended beverage. pH of guava whey blended beverage decreases slightly during storage periods (Mohiuddin Bhat et al., 2017).

2.8.1. Ohmic heating

While the traditional method maintains food safety, the high temperature causes nutritional losses and organoleptic alterations. The food sector has recently become interested in electrothermal and non-thermal approaches for both processing and preserving foodstuffs. Ohmic heating, also known as Joule heating or resistance heating, is a sort of electrothermal technology that heats food by passing an electric current through it. The passage of an electric current generates thermal energy, which is then used to heat food. The amount of heat produced is determined by the current created by the voltage gradient and electrical conductivity.The presence of electrodes in contact with food, the frequency range, and the waveform distinguish Ohmic heating from other electrothermal approaches (-Viorela Nistor et al., 2013). This method allows the product to be swiftly heated. The heat is dispersed evenly. Because of the presence of ionic components such as salts and acids in the food sample, electric current can be conducted. The range of 33-23.33 V/cm is investigated. The physicochemical parameters are observed to alter as the stress gradient, treatment period, and storage time are varied. Lower voltages and shorter treatment times preserve properties better. It has been discovered that ascorbic acid degrades more quickly at high voltage gradients (Chakraborty & Athmaselvi, 2014).

2.9. Impact of non-thermal technologies on guava beverages

Thermal processing is a commonly used method for microbiological safety and deteriorative enzyme inactivation in fruit juices and drinks (Sucupira et al., 2017). Heat treatment can cause physical and chemical changes that impair the biological activity of bioactive compounds. Thermal processing may be the source of nutritional and sensory quality loss (Fundo et al., 2018). Non-thermal technologies like as ultrasound and ozone are being researched as alternatives to thermal therapy to compensate for such losses (Alves Filho et al., 2020).

2.9.1. Ultra sound processing

The most frequent phenomenon encountered in liquid meal ultrasonic applications is cavitation. Cavitation is the process by which intense ultrasonic pulses cause vacuum bubbles to form in a liquid media. The "sponge effect" takes place when cavitation bubbles reach a size where they can no longer absorb energy, breaking down cell membranes and releasing bioactive compounds from vegetable tissue (Knorr et al., 2011).

In order to process the ultrasound, an ultrasonic generator made by Econosonics in Brazil is utilized. This generator has a titanium macro tip that has a diameter of 13 millimeters. The ultrasonic tip is kept submerged at a depth of 1.5 centimeters below the surface of the liquid throughout the treatment of 150 mL juice samples in triplicate in a glass jacked batch reactor of 6.5 centimeters in diameter and 9 centimeters in height. Temperature (20 degrees Celsius), exposure period (2, 6, and 10 minutes). The variables for this experiment include the length of exposure (two, six, and ten minutes), as well as the power (100, 300, and 500 W). The temperature of the processing is maintained precisely thanks to an inside thermostatic bath that features a circulating water system. Previous publications serve as a basis for making approximations on the potency density for each US power (W/cm2) (Li et al., 2004).

Table 2.3 Experimental parameters of ultrasonic processing

Assay number	Power(W)	Processing time (min)	Temperature (°C)
1	100	2	20
2	100	2	40
3	100	10	20
4	100	10	40
5	500	2	20
6	500	2	40
7	500	10	20
8	500	10	40
9	300	6	30

The potency density in W/cm2: 75.38 (100 W), 226.12 (300 W), and 376.89 (500 W) (Bevilacqua et al., 2018).

2.9.2. Ozone processing

Because of its antibacterial effectiveness, ability to inactivate enzyme, and lack of residues after processing, ozone technology is widely used in the food industry (Torres et al., 2011). Ozone has been given the green light by the Food and Drug Administration (FDA) to be used as an additive in the treatment, storage, and processing of food and food products. In addition to its usage in the processing of juice, ozone also has applications in the post-harvest management of fruits and vegetables. This is accomplished by using ozonized water rather than chlorine treatments (Horvitz & Cantalejo, 2014). The impact that ozone processing has on the antioxidant capacity of particular foods paves the way for novel applications of non-thermal technologies, such as increasing the amount of bioactive compounds present in the food matrix. Recent studies have investigated the effect that ozone has on the antioxidant capacity of food matrix, specifically in terms of the availability of bioactive chemicals (such as vitamin C, carotenoids, and anthocyanin) and the total phenolic content of fruits and their derivatives (Fundo et al., 2018).

For the ozone processing of orange and tangerine juice, batches consisting of 100 milliliters of each sample and three drops of a sterile antifoaming agent (Antifoam B emulsion, Sigma-Aldrich) are utilized (Almeida et al., 2015). An ozone generator & an oxygen supply container that has a flow control valve with a setting of 125 milliliters per minute each make up the ozone system. The treatment is carried out in a glass reactor in the form of a column. The reactor has a diameter of four centimeters and is fitted with a glass sintered plate at the bottom of the column. This plate ensures that the ozone gas is distributed evenly throughout the liquid. An ozone destroyer is located at the output of the system. The experiment is performed three times, with juice samples at room temperature (25 +-2) being exposed to varied ozone concentrations and processing times for each run. (Noguera et al., 2021).

Table 2.4 Experimental parameters of ozone processing

Assay code	Time (min)	Ozone loading (mg O3/ml)
A	2	0.074
B	4	0.148
C	6	0.296

Guava juice is tested for vitamin C (ascorbic acid, AA), yellow flavonoids, total phenolics (TPC), antioxidant activity, and enzymatic activity before (control) and after ultrasonic and ozone processing. When the influence of ultrasound and ozone on guava juice is investigated, ozone processing at medium and high ozone loads (Oz. B and Oz. C) has the greatest PC1 scores due to higher quantities of vitamin C (AA). Furthermore, low ozone loading (Oz. A) ozone processed juices showed higher total phenolics (TPC). Ozone is utilized in food processing as a gas and as ozonized water. The ozone load may have a deleterious impact on food matrices due to its high oxidant action. The key parameters influencing the phenolic component and vitamin C effect are ozone load and application form. (Sachadyn-Król & Agriopoulou, 2020).

2.9.3. Cold plasma technology

A non-thermal technology that has gained favor in recent years as an alternative method of food decontamination (Liao et al., 2017). The use of low temperatures over short periods of time to destroy germs, which is both energy efficient and effective. Furthermore, the breakdown of thermosensitive molecules, such as bioactive substances, is reduced while having no effect on the products' sensory qualities (Coutinho et al., 2018). In cold plasma technology, plasma is described as an ionized gas with a variety of interactions made up of neutral molecules, electrons, and particles of positive and negative ions in a balanced proportion (Pankaj & Keener, 2017).Although it has been demonstrated that cold plasma is effective for the decontamination of food (Coutinho et al., 2018), the influence of this technology on the physicochemical characteristics and preservation of compounds with health benefits in dairy goods has not been thoroughly investigated. (Yong et al., 2015).

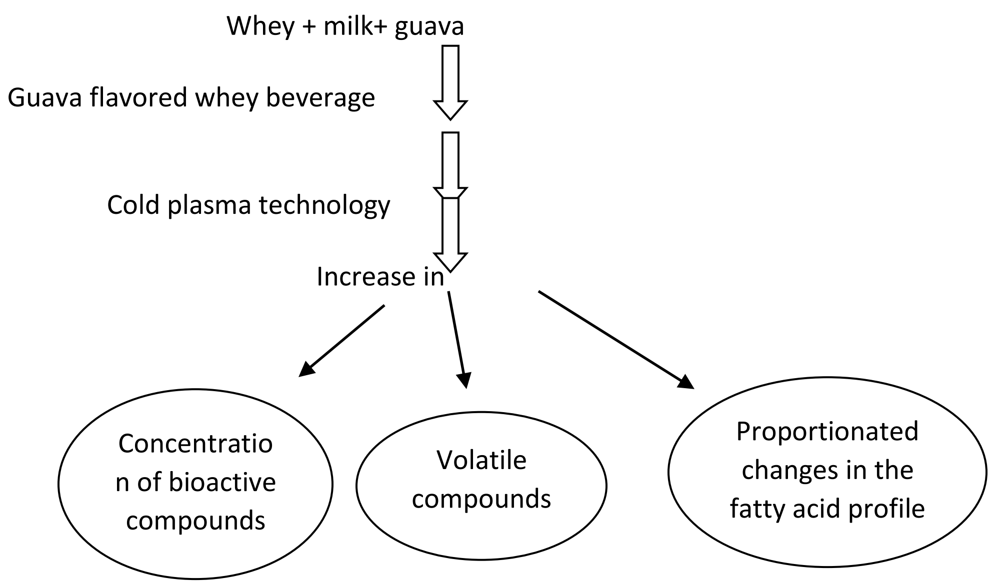
The impact of cold plasma technology (80 kV and nitrogen gas) on the bioactive compounds, volatile substances, and fatty acid profile of guava-flavored whey beverage for different processing times (5, 10, and 15 minutes), as well as gas flow rate (10, 20, and 30 mL per minute). The samples that have been exposed to plasma are contrasted with a typical pasteurized beverage (63–65 °C for thirty minutes).When compared to the beverages that had been treated with plasma, the beverage that had been thermally processed had a lower pH (p0.05). The use of heat to process dairy products results in a decrease in pH due to the production of organic acids (mainly formic acid) from lactose and the precipitation of calcium phosphate (from primary, secondary, or organic phosphate) (Fox, 1981). Both of these processes lead to the release of hydrogen ions. When compared to untreated or pasteurized goods, the pH values of products that were subjected to cold plasma treatment were found to be significantly higher (p.05)(Misra, 2016; Coutinhoetal., 2018).

Some of the components could have contributed to the higher pH of the plasma-treated beverages (Maheuxetal., 2015). Increased flow rates lead to higher concentrations of chemicals that produce acid, such as NOx, which react with the water in the meal to create nitric acid, lowering the pH of the medium (Yongetal., 2015). LowerpHlevelsarecommoninplasma-treatedgoods, particularlywhennitrogenisutilizedasthegas (Misra, 2016). Some of the constituents may have contributed to the elevation in pH in plasma-treated beverages (Maheux et al., 2015). Whey beverages have a strong buffering capacity, which may explain why the pH levels in mild cold plasma processing settings are so high.

2.9.3.1. Enzyme inactivation by cold plasma

The effect of plasma chemical substances on enzymes, that have a big role in keeping food fresh and are often used to measure how well food is being processed, is an important part of how they interact with food. Enzymes can be turned off by cold plasma because of how much power is put into the discharge, how much contact there is to reactive species, how much mass moves between the plasma and liquid phases, how complicated the structure is, and how stable the enzymes are in their local environment. The main way that something becomes inactive is when it loses its secondary structure. This happens when specific bonds break or when chemical changes are made to the side chains by the action of the many chemically active species that make up plasma.It is necessary to conduct additional study into the molecular interactions that chemical species in plasma have with proteins, as well as research into innovative methods to monitor and control the chemistry of plasma. It has been established that lysozyme can be deactivated by cold plasma. (Takai et al., 2012).

2.9.3.2. Cold plasma technology Flow chart for guava whey beverages



2.10. Benefits of guava based functional beverages

In traditional medicine, the leaves of the guava tree can be consumed to alleviate toothache pain, applied to wounds and ulcers, used to treat rheumatic pain, and cure rheumatism (Gutierrez et al., 2008). Epidemiological research has revealed that a high lycopene intake can help protect against cardiovascular disease (CVD) and reduce the risk of a number of malignancies, including cancers of the prostate, breast, lung, and digestive system (Parada & Aguilera, 2007). Guava juice's hypoglycemic effect is examined in normal and diabetic rats using a streptozotocin-induced diabetes mellitus paradigm. In both normal and alloxan-treated diabetic mice, acute intraperitoneal injection of 1 g/kg guava juice produced a significant hypoglycemic impact. As a result, it is suggested that guava be used to treat and/or prevent type 2 diabetes. Secondary plant metabolites can be found in guava, notably in the leaves, and these metabolites contain particular polyphenols that have antioxidant, anti-inflammatory, and antiviral activities(Gutiérrez et al., 2008). Guava is used to treat a range of diseases in traditional medicine, including hypertension, inflammation, pain, and diabetes (Daz-de-Cerio et al., 2017).Ascorbic acid (also known as vitamin C), flavonoids (also known as apigenin), and lycopene are the three guava components that are most commonly reported to have anticancer effects in vitro. Other guava components have also been hypothesized to have these properties. Although these three are the most important, the guava plant has a large number of additional compounds (leaves, fruits, bark, and so on) that may also have anticancer characteristics. One of the most common flavonoids is apiginin, which is a well-known antioxidant that may be found in a wide variety of fruits and vegetables. Anticancer therapeutics derived from polyphenolic chemicals that were created from flavonoids have been studied. Apigenin, which can be found in guava leaves, is known to decrease cell proliferation in a wide variety of cancer cell lines. This property of apigenin, which has been demonstrated to be advantageous by researchers in in vivo trials (Sato et al., 2010).

Antioxidants, according to experts, are molecules capable of mitigating the detrimental effects of toxic metabolites produced by both endogenous (as products that the body must discard) and exogenous (as a result of pollution). These products are known as oxygen free radicals, and they have a very high chemical reactivity, capable of causing impulsive cellular lesions and even causing cell death. Fruits, vegetables, and medicinal herbs are considered protective foods, and their consumption has increased as a result of their disease-fighting abilities. (Butu & Rodino, 2019).

Rising worldwide health awareness has recently increased demand for functional foods, particularly beverages that provide important nutrients, prevent nutrition-related diseases, and improve consumers' physical and emotional well-being (Raj *et al*. 2017; Kaur and Sigh 2017; Sharma *et al*. 2018).Many chronic diseases, such as cancer and cardiovascular disease, are causing an increase in morbidity and mortality worldwide. Several studies have found that alterations in the body's oxygen utilization and increased formation of reactive oxygen species (ROS) contribute to the development of many chronic diseases (Kaliora et al., 2006).

Fruit juices have been demonstrated to help prevent diabetes and other metabolic diseases, and they are high in antioxidants, which are vital for good health. Surprisingly, this gives pharmacological credence to the notion of value-added product design. (Upadhyay et al., 2018) Thus, antioxidant availability in our food influences oxidative stress protection (Kaliora et al., 2006). There is evidence that phytochemicals found in fruits and vegetables can provide antioxidant protection. As a result, it is hypothesized that dietary changes to improve availability to antioxidants are an effective method for preventing the formation of atherosclerotic lesions (Kaliora et al., 2006). Fruit and vegetable juices have been demonstrated to be high in bioavailable antioxidants and are thought to be the source of the health benefits ((Wootton-Beard & Ryan, 2011)). Antioxidant-rich meals are typically made from plant sources, which contain a variety of healthful components that make them a beneficial addition to the diet as a supplement to the body's antioxidant defence mechanism (Gunathilake, 2019).

Table 2.5 Results of different Treatments on Guava based beverages/Juices

Treatment	Product Type	Treatment condition	Result	References
Artificial and natural sweeteners	Guava RTS Beverage	100% Sugar	Maximum TSS observed	

		100% Splenda 50% aspartame +50% sugar	Maximum Acidity and minimum TSS observed Maximum Vitamin C and minimum acidity observed	
Thermal treatment	Guava-whey beverages	Different time temperature combinations are applied for 90 days storage period like 60°C for 15 min, 65°C for 25 min and 70°C for 35 min	Temperature time treatment did not affect protein content Slight decrease in lactose content and pH while slight increase in acidity of guava whey beverages	(Bhat et al., 2018) Mohiuddin Bhat et al., 2017)
Ohmic heating	Guava juice/ beverage	Ohmic heating at various voltage gradients applied like 13.33-23.33V/cm	The physicochemical properties retained more at low voltages and with less treatment time Ascorbic acid degrades faster at high voltage gradient Ohmic heating retained physicochemical properties for longer time	(Chakraborty & Athmaselvi, 2014)
Non thermal technologies	Product	Treatment condition	Result	References
Ultrasound processing	Guava juice	150ml juice in glass jacked batch reactor with ultrasonic tip submerged 1.5cm from liquid surface with ultrasound power of 100W, 300W	Guava juice is more susceptible to ultrasound processing due to increase of phenolics, vitamin C and antioxidant capacity.	(Noguera et al., 2021)

		and 500W for exposure time of 2,6 and 10 minutes respectively.	Target compounds like vit C and TPC increase due to extraction from food matrix due to cell disruption promoted by increasing ultrasonic intensity.	(Fonteles et al., 2012)
Ozone processing	Guava juice	100 ml batches of 3 sample with 3 drops of antifoaming agent and ozone load of 0.074, 0.148 and 0.296 mg of O3/ml with processing time of 2, 4 and 6 minutes	Ozone processing at medium and high ozone load presents the most negative score of PCI due to higher amount of vitamin C while ozone processed juice at low ozone load presents higher amounts of total phenolic compounds (TPC)	Sachadyn-Król & Agriopoulou, 2020) Fonteles et al., 2012)
Cold plasma technology	Guava flavored whey beverage	Nitrogen gas + 80 kv electric current at different processing times of 5, 10 and 15 mins and gas flow rates of 10, 20 and 30 ml per min on bioactive compounds, volatile compounds and fatty acid profile of guava flavored whey beverage.	The application of cold plasma resulted in higher pH values when compared to the untreated or pasteurized products. Higher flow rates lead to decrease in pH of medium. Cold plasma has been reported to inactivate a range of enzymes such as lysozyme, polyphenol oxidase and peroxidase. The guava-flavored whey beverages	(Takai et al., 2012 & (Misra et al., 2016) (Silveira et al., 2019).

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			treated by pasteurization or cold plasma had <3 MPN/mL for total and thermotolerant coliforms and no *Salmonella* sp. in 25 mL of product.	
Chemical preservative	Guava juice	0.05% sodium benzoate 0.005% sodium metabisulphite 0.04% sodium benzoate + 0.005% sodium metabisulphite	use of sodium benzoate and metabisulphite collectively is more effective in stabilizing ascorbic acid in guava juices as compared to when the two preservatives are used individually.	(K & K, 2013).

Conclusion and future perspective

The beverage market's virulent growth and development make it a highly competitive marketplace for traditional beverages. One of the elements fueling the expansion of the beverage market is the efficiency and convenience of beverages. To please modern consumers and compete in the beverage business, beverages must be cost effective, convenient, nutritional, and tasty. Aside from these features, many research evidences have demonstrated that functional whey beverages have the ability to be used in a variety of forms and can be an alternate healthy source of nutrients in the daily diet when compared to other thirst-quenchers. Guava beverages have a vital role in health promoting activities. blending guava pulp with different fruits for formation of functional beverages is emerging technique. Combined Effect of chemical preservatives such as sodium benzoate and metabisulphite are more suitable for stabilizing ascorbic acid contents of guava juice or beverages. effect of thermal treatment on guava-based beverages for self-life and extension and observing different organoleptic characteristics of guava including protein content, lactic acid and ph. all of these sows a decreasing trend. while acidity of guava-based beverages is increased during limited time storage. Other then all of these impact of non-thermal technologies helps in shelf-life extension by improving the quality of beverages. Different blends of guava-based fruits beverages are currently used in world which are easily available in drink form and helps in preventing from many hearts and coronary diseases. There is more to be done for guava based functional beverages specially as an antioxidant beverage and work should also be done on specific packaging regarding guava-based beverages which helps in shelf-life extension and easily available to consumer at normal cost. more non thermal technologies to be used to prevent from quality losses and using natural preservatives. Despite the hurdles and difficulties associated with rules and legal authority approval, new products with innovative ingredients and functionality are successfully manufactured. According to research, functional beverages containing active substances have a significant potential to improve health and prevent specific diseases. Functional beverages provide the possibility of promoting a healthy and active lifestyle, lowering healthcare expenditures, and promoting economic development.

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