Journal of Pure and Applied Agriculture (2024) 9(2): 66-75
ISSN (Print) 2617-8672, ISSN (Online) 2617-8680
http://jpaa.aiou.edu.pk/

Optimization of Aloe vera gel in *Ficus benghalensis* fruit jam for enhanced phytochemical contents and physicochemical properties

Ali Hassan*[1], Muhammad Kashif Iqbal Khan[1], Ali Usman[1], Mubeen Sultan Butt[2], Summaia Fordos[1], Iraj Fatima[1], Sharmeen Arif[1], Abdul Mueez Ahmad[1] and Muhammad Hussain Ghazali[3]

[1]National Institute of Food Science and Technology, University of Agriculture Faisalabad 38000, Pakistan
[2]Department of Food Engineering, University of Agriculture Faisalabad 38000, Pakistan
[3]School of Food Science and Engineering, South China University of Technology, Guangzhou, China, 511442

***Corresponding author: Ali Hassan (alihassan.86811@gmail.com)

Abstract

Ficus benghalensis fruit is known for its high mineral contents, fiber, carbohydrates, and antioxidants, making it an ideal ingredient for preparing functional food products. Aloe vera is a versatile and nutritious ingredient, widely used in food products. *F. benghalensis* fruit jam with different concentrations of aloe vera gel was made. According to this study, five treatments were prepared T_0 control (without aloe vera gel), T_1 (5% aloe vera gel), T_2 (10% aloe vera gel), T_3 (15% aloe vera gel), and T_4 (20% aloe vera gel), respectively. Jams were analyzed and characterized by physicochemical analysis, proximate analysis, antioxidant analysis, and total dietary fiber analysis. Results concluded that the addition of aloe vera had significant effect on the pH, titratable acidity, total sugars, and ascorbic acid contents, while non-significant effect on TSS of jam samples was observed. Results showed that aloe vera had a significant effect on carbohydrates, and moisture contents of jam samples, while a non-significant effect on crude fat, fiber, protein and ash contents were observed. Aloe vera gel significantly improved the phytochemicals and dietary fiber contents of jam samples. Future studies can explore the sensory evaluation and shelf-life analysis of Aloe vera-infused *F. benghalensis* fruit jam to further optimize its production and commercialization.

Keywords: Aloe vera gel, Banyan fruit, Functional foods, Food processing, Improved nutrition, Storage stability

To cite this article: Hassan, A., Khan, M. K. I., Usman, A., Butt, M. S., Fordos, S., Fatima, I., Arif, S., Ahmad, A. M., & Ghazali, M. H. (2024). Optimization of Aloe vera gel in *Ficus benghalensis* fruit jam for enhanced phytochemical contents and physicochemical properties. *Journal of Pure and Applied Agriculture, 9*(2), 66-75.

Introduction

It is known that fruit is a source of vitamins and minerals that promote health and are well established in biological processes (such as breathing, energy production, and immune response) that are well established in biological processes (such as breathing, energy production, and immune response). Fruits are excellent sources of bioactive components (carotenoids, vitamins, flavonoids, and phenolics) because they are antioxidants. Fruits are essential foods with higher functional and nutritional qualities. A diet high in fruits and vegetables is associated with a significantly decreased rate of various kinds of cancer in the population (Awolu, Okedele, Ojewumi, & Oseyemi, 2018). Globally, There's a rise in the development and consumption of functional foods. Functional foods are defined as food items that are exactly like traditional foods except for the addition of a biologically active chemical (BAC) (Putnik et al., 2018). The Japanese initially used the term functional foods in the 1980s, however, they are regulated but not usually recognized as legitimate things and lack a proper description and their connotation is regularly ambiguous (Ye, Georges, & Selomulya, 2018).

Ficus benghalensis is an enormous evergreen tree that belongs to the Moraceae family. *F. benghalensis* is also widely known as the "Indian banyan tree." It is native to South Asia and thrives in arid locations throughout India, Sri Lanka, Pakistan, and Bangladesh. It is also widely farmed in practically every moist tropical area throughout the world (Gopukumar et al., 2016). It possesses extraordinary therapeutic properties that have assisted in the treatment of numerous life-threatening disorders. This tree was extensively used as medicine in traditional medicinal systems like Unani, Siddha, and Ayurveda, and homoeopathy. (Kmail et al., 2018). The fruit, which is cherry-sized and red, has a fleshy pericarp and is edible for both animals and humans. The figs of the *Ficus benghalensis* tree are not only delicious but also rich in nutrients. They provide a healthy amount of dietary fiber, minerals and vitamins, especially vitamin C, potassium, and antioxidants. Consuming *F. benghalensis* fruit can help support digestive health, boost immunity, and provide essential nutrients for overall well-being. It is high in secondary metabolites (Jayasree Radhakrishnan & Venkatachalam, 2020).

Banyan fruits are high in mineral content, fiber, and carbohydrates. The composition of banyan fruit (dry basis) was the wet basis (71.02%), ash (2.83%), crude fat (8.66%), fiber (17.08%), protein (4.83%), and carbohydrate (66.63%), respectively. Fruits are high in ash (minerals), carbs, and crude fibers, and are a good source of energy. A high mineral content improves digestion by increasing enzyme activity. Consumption of crude fiber increases faecal bulk and hence the pace of intestinal transit. Total metabolizable energy (363.86 kcal/100 g) is an excellent source for human nutrition (Bandekar, Nagavekar, & Lele, 2013). The fruit has 276 mg/g polyphenols, which aid in the chelation of metal ions (particularly copper and iron), which function as pro-oxidants. (Jayasree Radhakrishnan & Venkatachalam, 2020). A high-energy edible product may be produced by properly processing banyan fruit. (Bandekar et al., 2013).

Aloe barbadensis is a plant that is robust, seasonal, tropical, drought-contrary, pulpy Liliaceae plant that has been utilized for a range of therapeutic uses in the past. Aloe vera is a Plant with no stems or extremely short stems that grows to a height of 60-100 cm and spreads by offshoots (Muniz-Ramirez et al., 2020). The aloe vera plant's leaves contain a gel that is high in antioxidants, vitamins, minerals, and amino acids, making it a popular ingredient in various beauty and wellness products. The inner gel of aloe vera consists of about 75 components that are biologically active, which are beneficial for healing and medicinal purposes for millennia (Kumar et al., 2019). For a very long time, aloe vera was used as a medicinal herb for several therapeutic purposes. The food and beverage industry is a prospective market for Aloe vera. The Food and Drug Administration (FDA) has certified Aloe juice for oral use as a "dietary supplement" in the United States. As consumer interest in natural and functional foods continues to grow, aloe vera's presence in the food industry is expected to expand further, offering both nutritional benefits and a touch of botanical elegance to a variety of food products. Aloe vera is included in the European Commission Annex as one of the "flavouring compounds" used in the feeding industry (Sonawane, Gokhale, Mulla, Kandu, & Patil, 2021). Jams are well known for their accessibility, sensorial qualities, and affordability. They are typically canned and packed in clean vessels after production. The versatility of jams and jellies as a condiment, ingredients in recipes, or toppings for various dishes has contributed to their expanding market appeal. Jams, jellies, and preserves are gaining popularity across the world. Customers of all ages consume these things regularly in areas such as Europe and North America. The objective of this research is to develop and characterize the functional jam based on *F. benghalensis* fruit, and to evaluate the nutritional and sensory attributes of newly developed jam for consumer acceptability.

Material and Methods

Procurement of raw material

F. Benghalensis fruit and aloe vera leaves were obtained from the University of Agriculture Faisalabad. All other ingredients and preservatives are obtained from the local market of Faisalabad.

Preparation of raw materials

After washing *F. benghalensis* fruit, and removing debris, blending was done through the blender. Aloe vera leaves were cleaned, and the gel was manually collected from the interior after the outer layer was cut away with a sharp knife. The blend was kept at 4°C in a cool environment.

Preparation of jams

F. Benghalensis fruit jam was prepared by the method used by Nafri et al. (2021). For jam preparation, 300g *F. benghalensis* fruit pulp and 300g sugar were taken. The mixture was heated in a metal pan on a slow flame. In the end, a few drops of lemon juice were added as a preservative. In the other 4 treatments, 5%, 10%, 15%, and 20% aloe vera gel were added in the end and brix° was noted with the help of a refractometer. The jam was removed from heating when its brix° was reached between 65-70°. The jam was filled in glass jars and kept at room temperature for further chemical evaluation.

Physicochemical analysis

pH

Using a pH meter, the jam sample's pH was calculated using the method outlined by Dos Santos et al. (2020).

Total soluble solids

TSS of *F. benghalensis* fruit jam was calculated using the prescribed method (Chalchisa, Zegeye, Dereje, & Tolesa, 2022). Total soluble solids were measured using the digital refractometer.

Total titratable acidity

The total acidity of jam samples was determined using the technique described by Rafique et al. (2023).

Moisture contents

Moisture contents of jam samples were measured with a digital moisture meter according to the method used by de Ridder et al. (2017).

Total sugar contents

The total sugar contents of the food product can be described as all monosaccharides existing in the food or fruit, obtained from any source. The total sugars of *F. benghalensis* jam were measured based on the procedure outlined by Chalchisa et al. (2022).

Ascorbic acid contents

The recommended method was used to measure the ascorbic acid contents (Diabagate et al., 2020).

Total Dietary fiber contents

The total dietary fiber of jam samples was determined using the procedure outlined by Bhatt & Gupta, (2024). A MegaZyme kit was used to analyze dietary fiber, involving heat-stable alpha-amylase, protease, and amyloglucosidase treatments to break down starch and protein. The mixture was then treated with ethanol, filtered, and dried to obtain a residue, which was weighed to calculate dietary fiber.

The weight of protein and ash was deducted from the residue weight to determine the final dietary fiber contents.

Proximate analysis

Fat contents

Crude fat was determined using protocol from Akhter et al., (2022). Soxhlet Apparatus was used for this purpose. A 5g sample (moisture-free) was folded in a Whatman filter paper thimble and inserted in the extraction tube of the apparatus. Until the completion of the sixth siphon, the procedure was kept continuous. Then, the sample was placed in a hot air oven until the persistent mass of dry matter was attained. The fat percentage was calculated as:

$$Crude\ fat\ (\%) = \frac{initial\ weight - final\ weight}{weight\ of\ sample} \times 100$$

Protein contents

The crude protein contents were analyzed by the Kjeldahl method (Hasani & Yazdanpanah, 2020). A 2g jam sample was digested with 98% Sulphuric Acid and a digestion mixture in a Kjeldahl apparatus, then neutralized with distilled water. The mixture was then treated with Sodium Hydroxide and Boric Acid solutions and steamed until colorless. The resulting solution was titrated with 0.1N H2SO4 until a color change occurred, and the crude protein percentage was calculated from the observed value.

$$N\ (\%) = \frac{V1 \times V2\ \times 0.0014}{Weight\ of\ Sample\ \times V3} \times 100$$

Where
V_1 = Volume of 0.1N H_2SO_4
V_2 = Volume of dilution (250 ml)

Crude fiber contents

The enzymatic gravimeter method specified by Pahari et al., (2022) was utilized to determine the crude fiber contents of power bites. The residue was treated with 1.25% NaOH solution until alkali-free, then dried in an oven at 100°C for 3-4 hours until uniform weight. The samples were further heated to smoke-free on a flame, then ashed in a muffle furnace at 550°C for 4 hours. The resulting ash was cooled, weighed, and recorded for further calculation.

$$Crude\ fiber\ (\%) = \frac{weight\ of\ sample\ after\ digestion\ - weight\ of\ ash}{Initial\ weight} \times 100$$

Ash contents

The ash contents of *F. Benghalensis* fruit jam were assessed following the procedure given in Bhattarai & Kusma (2022). 3 grams of the sample were put into a crucible and subjected to direct flame from a burner for charring until no fumes were observed. Subsequently, the sample was incinerated in a muffle furnace at a temperature range of 550-600 °C for 5-6 hours, resulting in a greyish white colored residue. The ash contents of the sample were determined using the following formula:

$$\text{Ash (\%)} = \frac{Weight\ of\ sample\ before\ charring}{Weight\ of\ sample\ after\ charring} \times 100$$

Nitrogen-free extract

The carbohydrate contents of the jam samples were calculated by deducting the percentages of moisture, fat, ash, crude protein, and crude fiber from one hundred (Kaur et al., 2022).

Phytochemical analysis

Preparation of extracts

Each sample weighed out to be around 2 g, and 50ml of methanol was used to extract it. The extraction process was held at 60 degrees Celsius with stirring. Whatman no. 3 filter paper was used to filter each extract. filled a 50-milliliter volumetric flask appropriately, and then placed it in the dark until analysis.

Total phenolic contents

The number of phenolic compounds in the extracts was measured using the Folin-Ciocalteu technique. Total phenolic contents was determined by the method used by Handique et al. (2020) with some changes. To analyze the jam samples, 40 mL of the sample extract or the gallic acid standard was combined with 1.8mL of Folin-Ciocalteu reagent, which had been previously diluted 10-fold with distilled water. Afterward, 1.2mL of 7.5% sodium bicarbonate was transferred to the mixture. The resulting mixture was allowed to remain at room temperature for 5 minutes. After 60 minutes of standing at room temperature, a spectrophotometer was used to detect the wavelength at 765 nm. The results were expressed as mg gallic acid equivalents (GAE) per gram of the sample analyzed, following the method explained by Nguyen & Chuyen (2020).

Total flavonoid contents

The total flavonoid contents of the samples were determined by following the method described by Kouadio Atta et al. (2021), using Catechin as a standard. The absorbance of each standard solution and the sample solutions was measured as a specific wavelength using a spectrophotometer. The results were given in milligrams of catechin equivalent per unit of sample (e.g. per gram).

Free radical scavenging activity (DPPH)

Each sample’s free radical scavenging activity was determined by following the process explained by Saeed Alkaltham et al. (2020). Firstly, centrifugation of the jam sample was done at 15ºC for 15 minutes at 6000 rpm. The 0.1 ml supernatant was taken and diluted up to 0.5 ml with 70% ethanol. Then, the above mixture was mixed with 0.5 ml of DPPH 0.2 mM solution. The sample was placed on a vortex mixer or vigorous mixing and kept for 15 minutes at desired temperature in a dark place. Each sample's absorbance was measured by using a spectrophotometer at 517 nm.

Storage study

A storage study was conducted after 0, 15, 30, 45 and 60 days by using physicochemical analysis (Rana et al., 2021).

Statistical analysis

The collected data was statistically analyzed by analysis of variance (ANOVA) technique and subjected to proper statistical design to measure the significance level (Montgomery, 2017).

Results and Discussion

Proximate analysis

Moisture contents

The moisture contents varied from 29.97-35.90%. The mean values of moisture contents for different treatments (T_0, T_1, T_2, T_3, and T_4) were (29.97±0.8, 30.33±0.6, 32.02±0.5, 33.72±0.4 and 35.9±0.2%), respectively, and given in Table 1. A considerable increase in moisture of jam samples was noted because aloe vera gel was used in a jam containing 98% water (Alam et al., 2022). The moisture contents of this study are comparable to the literature on cashew apple jam with moisture contents of 30.38% (Nurerk & Junden, 2021). Akusu and Chibor, (2020) also reported the results of moisture contents ranging from 28.48-41.23% in the preparation of jam produced from different peels of fruits.

Crude fat

The values of crude fat contents after the addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 1. The mean value of crude fat contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (0.19±0.03, 0.21±0.04, 0.18±0.05, 0.14±0.09, and 0.16±0.04%), respectively. Results revealed that aloe vera addition had non-significant effect on the crude fat percentage of jam samples. Likewise, Ahmad and Ahmad, (2023) reported that aloe vera gel does not affect fat contents of jam because in aloe vera gel, fat contents were found in trace amounts. The results of the current study are lower than the results of composite jam produced from orange, apple, and date powder in which fat contents ranged from 0.49-8.99% (Omolara, Nkechinyere, & Gbohunmi, 2022). These results were comparable with literature on pineapple and cucumber jam with fat contents ranging from 0.23-0.12% (Ogori et al., 2021).

Crude fiber

The results of crude fiber contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 1. The mean values of crude fiber contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (1.87±0.08, 1.84±0.06, 1.82±0.05, 1.79±0.1, and 1.73±0.04%), respectively. The results showed that addition of aloe vera gel in *F. benghalensis* fruit jam did not affect the crude fiber contents significantly which varied from 1.73-1.87%, because aloe vera has small amounts of crude fiber contents. Alokun-adesanya and Adebisi, (2020) reported that crude fiber contents of strawberry jam with different fruit blends ranged from 0.42-0.64%. The results are also correlated with the literature on cashew apple jam with crude fiber contents 0.16% (Kouadio Atta et al., 2021).

Crude protein

The crude protein values after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 1. The mean values of crude protein contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (0.49±0.12, 0.39±0.08, 0.43±0.02, 0.55±0.02, and 0.47±0.04%), respectively. The results showed that that addition of aloe vera gel in jam did not affect the crude protein contents significantly which varied from 0.39-0.55%, because aloe vera has small amounts of crude protein contents. The results are correlated with dragon fruit jam with protein contents ranged from 0.15-1.15% (Castro et al., 2021). Likewise, Younas et al. (2021) reported that there were non-significant differences in the protein contents of different calcium fortified jelly treatments with protein contents ranged from 0.40-0.55%.

Ash contents

The ash contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 1. The mean value of ash contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (0.48±0.07, 0.42±0.08, 0.45±0.05, 0.44±0.03, and 0.51±0.10%), respectively. The results showed that addition of aloe vera gel in *F. benghalensis* fruit jam did not affect the ash contents significantly varied from 0.42-0.51%, because aloe vera has small amount of ash contents (Munir, 2022). The current findings are correlated with orange jam with ash contents ranging from 0.41-0.89% (Teixeira et al., 2020).

Carbohydrate contents

The values of carbohydrate contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 1. The mean value of carbohydrates contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (67.01±0.8, 66.8±1.04, 65.09±0.18, 63.35±0.99, and 61.23±0.67%), respectively. The results indicate that there was a significant difference between different treatments as the percentage of aloe vera increases. The percentage of carbohydrate contents decreased as the concentration of aloe vera increased because aloe vera has lower amounts of carbohydrates reported by Vijetha et al. (2021). The results are slightly higher than the results of literature on pineapple, watermelon and apple jam with carbohydrate contents ranged from 33-58.96% (Salam et al., 2020).

Table 1 Proximate composition of *F. benghalensis* fruit jam with different concentrations of aloe vera gel

Treatments	Moisture (%)	Fat (%)	Fiber (%)	Protein (%)	Ash (%)	Carbohydrates (%)
T_0	29.97±0.8	0.19±0.03	1.87±0.08	0.49±0.12	0.48±0.07	67.01±0.8
T_1	30.33±0.6	0.21±0.04	1.84±0.06	0.39±0.08	0.42±0.08	66.8±1.04
T_2	32.02±0.5	0.18±0.05	1.82±0.05	0.43±0.02	0.45±0.04	65.09±0.18
T_3	33.72±0.4	0.14±0.09	1.79±0.1	0.55±0.02	0.44±0.03	63.35±0.99
T_4	35.9±0.2	0.16±0.04	1.73±0.04	0.47±0.04	0.51±0.09	61.23±0.67

Physicochemical analysis

pH

The results of pH after adding aloe vera gel in *F. benghalensis* fruit jam are presented in Table 2. The mean value of pH of jam samples (T_0, T_1, T_2, T_3, and T_4) were (4.52±0.03, 4.38±0.02, 4.32±0.02, 4.16±0.01, and 4.07±0.05), respectively. The results showed that the addition of aloe vera gel in *F. benghalensis* fruit jam significantly affects the acidity of jam samples. The addition of aloe vera gel, which is acidic, decreases the pH therefore increases the acidity of the jam (Ali, 2021). During storage, the lowest value of pH 4.07±0.05 for T_4 was calculated at 0 days which decreased to 3.85±0.02 and 3.46±0.05 on the 14th and 28th days of storage, respectively. It continued to decrease to 3.20±0.02 on the 45th day of storage and further decreased to 2.78±0.9 at 60 days of storage. There was a highly significant effect on the pH of jam samples during storage. This decrease in pH during storage is due to the formation of acidic compounds from the breakdown of sugar. Likewise, Rafique et al., (2023) reported results during the storage study of pH of jam prepared from karonda fruit with pH ranged from 3.27-4 during 120 days of storage. The results of this study is closely related to the literature on strawberry jam with pH ranged from 3.28-3.61 (Quesada Matos et al., 2022).

Table 2 pH of *F. benghalensis* fruit jams containing aloe vera during storage

Treatments	0 day	14 days	28 days	45 days	60 days
T_0	4.52±0.03	4.26±0.07	3.98±0.03	3.56±0.03	3.14±0.03
T_1	4.38±0.02	4.04±0.05	3.81±0.04	3.41±0.01	3.08±0.09
T_2	4.32±0.02	4.09±0.08	3.71±0.07	3.32±0.06	2.98±0.08
T_3	4.16±0.01	3.94±0.03	3.51±0.09	3.18±0.03	2.82±0.06
T_4	4.07±0.05	3.85±0.02	3.46±0.05	3.2±0.02	2.78±0.09

Total soluble solids

The effect of TSS after the incorporation of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 3. The mean value of TSS of jam samples (T_0, T_1, T_2, T_3, and T_4) were (66.22°±1.34, 65.57°±1.71, 67.27°±0.08, 66.84°±1.04, and 67.15°±0.14), respectively. The results showed that the inclusion of aloe vera gel in *F. benghalensis* fruit jam had non-significant effect on the TSS of jam samples. As the aloe vera percentage (0-20%) increased, there was no significant difference in total soluble solids reported by Ali (2021). During storage, the lowest values for TSS 67.15°±0.14 of T_4 was calculated at 0 days which increased to 67.49°±1.33 and 68.03°±0.03 on the 14th and 28th days of storage, respectively. It continued to increase to 68.76°±1.24 on the 45th day and further increased to 69.43°±1.15 on the 60th day of storage. Results obtained from the storage study indicated that with the increased storage time from 0 to 60 days, TSS contents increased from 67.15-69.43°. This increase may be due to the hydrolysis of polysaccharides to release simple soluble sugar into products reported by Rana et al. (2021). The results of this research is closely correlated to the literature on banana-pineapple jam in which TSS of different samples were in range between 65-70° reported by Nookaratnam et al. (2023).

Table 3 TSS of *F. benghalensis* fruit jams containing aloe vera during storage

Treatments	0 day	14 days	28 days	45 days	60 days
T_0	66.22±1.34	67.42±1.33	68.36±1.24	69.46±1.71	70.20±1.33
T_1	65.57±1.71	66.23±1.24	67.20±1.33	68.06±0.08	69.16±1.71
T_2	67.27±0.08	67.92±1.71	68.67±1.24	68.70±1.33	70.76±1.24
T_3	66.83±1.04	68.51±0.08	68.30±0.08	70.21±1.71	70.73±1.33
T_4	67.15±0.14	67.49±1.33	68.03±0.33	68.76±1.24	69.43±1.15

Titratable acidity

The results of titratable acidity after the addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 4. The mean values of titratable acidity of jam samples (T_0, T_1, T_2, T_3, and T_4) were (0.39±0.03, 0.42±0.05, 0.46±0.09, 0.49±0.03, and 0.52±0.04), respectively. The results showed that the addition of aloe vera gel in *F. benghalensis* fruit jam significantly affects the titratable acidity of jam samples because aloe vera itself has acidic compounds in it. The results are slightly lower than the literature on aloe vera-based apricot beverages with titratable acidity ranging from 1.11-1.43 (Sharma et al., 2022). During storage, the lowest value of titratable acidity 0.52±0.04 for T_4 was observed at 0 days which increased to 0.59±0.07 and 0.67±0.08 on the 14th and 28th days of storage, respectively. The titratable acidity further increased to 0.71±0.03 on the 45th day and the highest acidity 0.79±0.05 was calculated on the 60th day of storage. The increase in acidity may be attributed to the degradation of ascorbic acid, weekly ionized acids and their salts during storage, formation of acids by breakdown of polysaccharides like pectin, and oxidation of reducing sugars (Nookaratnam et al., 2023). The results are similar to the literature of apricot sea buckthorn blended jam with titratable acidity ranged from 0.60-0.68% (Abbas, 2021).

Table 4 Titratable acidity of *F. benghalensis* fruit jams containing aloe vera during storage

Treatment	0 day	14 days	28 days	45 days	60 days
T_0	0.39±0.03	0.47±0.04	0.57±0.07	0.63±0.09	0.69±0.04
T_1	0.42±0.05	0.49±0.09	0.6±0.03	0.66±0.02	0.72±0.09
T_2	0.46±0.09	0.54±0.08	0.62±0.04	0.68±0.04	0.75±0.07
T_3	0.49±0.03	0.57±0.03	0.64±0.09	0.69±0.06	0.77±0.03
T_4	0.52±0.04	0.56±0.07	0.67±0.08	0.71±0.03	0.79±0.05

Total sugars

The values of total sugar after the addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 5. The mean value of total sugar of jam samples (T_0, T_1, T_2, T_3, and T_4) were (69.03±1.70, 68.93±1.82, 68.15±0.6, 67.63±1.15, and 67.33±0.6%), respectively. Results showed that there was a significant decrease in the total sugar contents of different jam samples as the aloe vera percentage increased from 0-20%, because aloe vera itself is acidic, so it minimizes the total sugar contents of jams. Similar results were reported by Vijetha et al. (2021) in the production of a nutraceutical health drink using aloe vera as a base component with total sugar contents 9.46%. The results of current study are higher than the results of literature on some local jams and jelly with total sugar contents ranged from 46.9-62.29% (Saha & Ferdous, 2022). During storage, the lowest values of total sugar contents 67.33±0.6 for T_4 were found at 0 days. Then total sugar contents tend to increase to 68.23±0.7 and 68.92±0.69 at the 14th and 28th days of storage time. Total sugar contents further increased to 69.42±0.5 and 70.26±0.8 on the 45th and 60th days of storage, respectively. The increased total sugar levels can be due to the hydrolysis of polysaccharides into sugars and the inversion of sugar. Similar results were reported by Nafri et al. (2021) in the preparation of papaya jam with total sugar contents ranged from 66.8-70.4%.

Table 5 Total sugars of *F. benghalensis* fruit jams containing aloe vera during storage

Treatments	0 day	14 days	28 days	45 days	60 days
T_0	69.30±1.70	69.89±0.69	70.17±0.5	70.94±0.8	71.66±0.5
T_1	68.93±1.82	69.43±1.82	69.93±1.15	70.36±0.69	71.28±1.15
T_2	68.15±0.6	68.83±0.5	69.19±1.82	69.91±0.7	70.64±1.82
T_3	67.63±1.15	68.23±1.15	68.92±0.7	69.42±1.15	70.26±0.69
T_4	67.33±0.6	68.15±0.7	68.45±0.69	69.13±0.5	69.87±0.8

Ascorbic acid contents

The ascorbic contents varied from 8.19 to 9.98mg. The mean value of ascorbic acid contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (8.19±0.99, 8.83±0.12, 9.14±0.26, 9.62±0.13, and 9.98±0.31mg), respectively. Results indicate that as the percentage of aloe vera increases, the ascorbic acid contents increase in *F. benghalensis* fruit jam samples because aloe vera itself has ascorbic acid contents. The results are slightly higher than the literature on aloe vera-based formulated beverage in which ascorbic acid contents increases from 4.16-6.86mg (Alam et al., 2022). The results are also comparable with literature on aloe vera-based strawberry and ginger squash in which ascorbic acid contents ranged from 14.70-15.14mg (Shagiwal & Deen, 2022). Likewise, Khan et al. (2020) reported slightly higher results on fig fruit jam with ascorbic acid contents ranged from 13.21-19.12 mg.

Phytochemical analysis

Total phenolic contents

The TPC of jam samples ranged from 134.51-155.73 mg GAE/100g. The total phenolic contents calculated in *F. benghalensis* fruit pulp was 229.836 mg GAE/100g. Total phenolic content was higher in raw fruit pulp due to minimal processing and water contents, whereas jam production involved heat treatment, sugar addition, and enzymatic reactions that reduced phenolic compounds. This resulted in lower total phenolic contents in jam samples compared to raw fruit pulp. The effect of total phenolic contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Figure 3.12. The mean value of total phenolic contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (134.51±0.98, 139.71±0.96, 144.69±0.75, 151.92±0.29, and 155.73±0.64mg GAE/100g), respectively. The results indicated that when the concentration of aloe vera gel was increased (0-20%), there was a significant difference in the phenolic contents of the jam. As the concentration of aloe vera rises from 0-20%, the total phenolic contents increase because aloe vera itself has total phenolic contents. The total phenolic contents of formulated beverages based on aloe vera and *Jamaican sorrel* also increase as the percentage of aloe vera increases with total phenolic contents ranged from

455.019-840.703 mg GAE/100g (Mori-mestanza et al., 2022). Kausar (2020) also reported that aloe vera-based orange beverages had an increased amount of total phenolic contents ranged from 402.67-593.93 mg GAE/100 g. The results are also comparable with literature on reduced calorie aloe vera-based pineapple jam (Dubey et al., 2021).

Total flavonoid contents

The values of total flavonoid contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 6. The mean value of total flavonoid contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (283.95±4.05, 289.48±0.96, 294.22±1.02, 299.40±1.94, and 306.18±1.64 mg CE/100g), respectively. The total flavonoid contents calculated in *F. benghalensis* fruit pulp was 463.83 mg CE/100 g. Raw fruit pulp had more flavonoids because it was not processed much, but making jam involved heat and oxidation that destroyed some of these compounds, resulting in lower flavonoid levels in jam compared to raw fruit pulp. The results are comparable with the literature on quince jam in which total flavonoid contents calculated were 15.8 and 13 mg CE/100g for quince pulp and quince jam, respectively (Cascales & García, 2020). The results indicated that when the concentration of aloe vera gel increased (0-20%), there was a significant difference in the total flavonoid contents of the jam samples. As the concentration of aloe vera rises from 0-20%, the total flavonoid contents increase because aloe vera itself has TFC contents. Likewise, Bista et al. (2020) reported that methanolic extract of aloe vera showed total flavonoid contents which was 73.26 mg CE/100g. The results are comparable with literature of *Physalis spp*. Fruit jam with total flavonoid contents ranged from 127.22-311.9 (Pérez-Herrera et al., 2020a).

DPPH free radical scavenging assay

The DPPH free radical scavenging assay percentage are presented Table 6. The mean value of DPPH activity of jam samples (T_0, T_1, T_2, T_3, and T_4) were (28.53±1.02, 31.32±0.96, 34.45±1.02, 36.44±1.94, and 40.69±1.64%), respectively. The DPPH activity exhibited by *F. benghalensis* fruit was 38.88% which is higher than the T_0, T_1, T_2, T_3 and lower than T_4 treatment. This is because T_4 treatment had 20% aloe vera gel and aloe vera itself has antioxidant activity. Reza et al. (2012) also reported that DPPH activity was high in blueberry jam which was 12.018% and low in blueberry fruit pulp which was 6.041%. The results indicated that as the concentration of aloe vera rises from 0-20%, the DPPH free radical scavenging assay percentage increase because aloe vera itself has an antioxidant effect. Solaberrieta et al. (2022) stated that aloe vera has a high level of antioxidant activity ranged from 49.9-73.4%. Hes et al. (2019) also reported that various parts of aloe vera have good antioxidant activity ranged from 56.75-80.20%. The current findings are also correlated with literature on kinnow jam with DPPH percentage ranged from 44.29-45.18% (Purewal et al., 2022).

Total dietary fiber

Total dietary fiber values ranged from 1.60-1.91g. Total dietary fiber contents calculated in *F. benghalensis* fruit was 2.24 g which was higher than jam treatments because cooking jam can break down some of the dietary fiber, making it less effective. The results of total dietary contents after addition of aloe vera gel in *F. benghalensis* fruit jam are presented in Table 6. The mean value of total dietary fiber contents of jam samples (T_0, T_1, T_2, T_3, and T_4) were (1.60±0.02, 1.68±0.56, 1.76±0.02, 1.84±0.05, and 1.91±0.02 g), respectively. Results revealed that aloe vera has a significant effect on the total dietary fiber contents of *F. benghalensis* fruit jam because aloe vera has a significant amount of dietary fiber contents. Likewise, Bista et al. (2020) reported that aloe vera gel contains a good 0.8% of dietary fiber contents. The results of the current study are comparable with the literature of *Physalis spp*. Fruit jam with dietary fiber ranges from 0.6-2.1g (Pérez-Herrera et al., 2020b). The results of total dietary fiber contents of different fruit jams were also similar which ranged from 0.38-0.54 g (Mohd Naeem et al., 2017). Results are correlated with literature on mulberry-enriched fruit jam with dietary fiber contents ranged from 1.8-6.01g (Yadav et al., 2020).

Table 6 Phytochemical contents, total dietary fiber and ascorbic acid contents of *F. benghalensis* fruit jams containing aloe vera during storage

Treatments	TPC (mg/GAE)	TFC (mg/g)	DPPH (%)	Total Dietary Fiber (g)	Ascorbic acid (mg)
T_0	134.51±0.98	283.95±4.05	28.53±1.02	1.60±0.02	8.19±0.99
T_1	139.71±0.96	289.48±0.96	31.32±0.96	1.68±0.56	8.83±0.12
T_2	144.69±0.75	294.22±1.02	34.45±1.02	1.76±0.02	9.14±0.26
T_3	151.92±0.29	299.40±1.94	36.44±1.94	1.84±0.05	9.62±0.13
T_4	155.73±0.66	306.18±1.64	40.69±1.64	1.91±0.02	9.98±0.31
Fresh Fruit	229.836±0.89	463.83±1.78	38.88±1.33	2.24±0.04	

Conclusion

The addition of aloe vera gel to *F. benghalensis* fruit jam enhanced its nutritional and sensory properties, making it a valuable ingredient for functional food products. The optimal concentration of aloe vera gel was 20%, which significantly improved phytochemical contents, dietary fiber, and sensory profile. This study demonstrates the potential of aloe vera gel as a natural additive to develop nutritious and consumer-acceptable jam products. The results of this study have broader implications for the development of sustainable, nutrient-dense, and consumer-acceptable food products, which will help meet the rising demand for functional foods that promote general health and wellbeing.

References

Abbas, Z. (2021). Quality assessment of apricot jam supplemented with Sea buckthorn pulp. *Pure and Applied Biology*, *10*(3), 826–834. https://doi.org/10.19045/bspab.2021.100085

Ahmad, H., & Ahmad, H. (2023). *Global Journal of Food Science & Human Nutrition Evaluation of Different Processes to Stabilize and Preserve Pure Aloe Vera Gel for the Development of Ready to Serve Functional Drinks*. *1*, 1–10. Retrieved from www.gjfshn.com

Akhter, M. J., Hosain, M. M., Halim, M. A., Prabin, M., Parvin, S., Siddika, A., … Al-Amin, M. (2022). Consumer Acceptance and physicochemical properties of developed carambola (*Averrhoa carambola*) Candy. *World Journal of Engineering and Technology*, *10*, 458–471. https://doi.org/10.4236/wjet.2022.102027

Akusu, O. M., & Chibor, B. S. (2020). Pectin strength of common varieties of plantain peels used in the production of jam/marmalade. *Asian Food Science Journal*, *19*(3), 1–9. https://doi.org/10.9734/afsj/2020/v19i330238

Alam, S., Ahiduzzaman, M., Islam, M., Haque, M., & Akanda, M. (2022). Formulation and senso-chemical evaluation of aloe vera (Aloe Barbadensis Miller) based value added beverages. *Annals of Bangladesh Agriculture*, *25*(1), 43–54. https://doi.org/10.3329/aba.v25i1.58154

Ali, W. (2021). Quality evaluation of peach jam prepared by incorporation of Aloe vera gel. *Pure and Applied Biology*, *10*(4), 935–944. https://doi.org/10.19045/bspab.2021.100097

A Alokun-adesanya, O., & Adebisi, K. (2020). Proximate composition , amino acid profile and vitamin C contents of different date jam blends. *International Journal of Women in Technical Education and Employment*, *1*(2), 1–7.

Awolu, O. O., Okedele, G. O., Ojewumi, M. E., & Oseyemi, F. G. (2018). Functional jam production from blends of banana, pineapple and watermelon pulp. *International Journal of Food Science and Biotechnology*, *3*(1), 7–14.

Bandekar, H., Nagavekar, N., & Lele, S. S. (2013). Studies on banyan (*Ficus benghalensis* L.): Characterization of fruit and callus induction. *Journal of Scientific and Industrial Research*, *72*, 553–557.

Bhatt, S., & Gupta, M. (2024). Exploration of soluble dietary fiber extraction technique for enhancing physicochemical and structural properties of mango and pomegranate peel. *Biomass Conversion and Biorefinery*, *14*(2), 2545–2560. https://doi.org/10.1007/s13399-022-02545-7

Bhattarai, S., & Kusma, R. (2022). Preparation and quality evaluation of sugar and honey based beetroot candies. *Sustainability in Food and Agriculture*, *3*(1), 15–18. https://doi.org/10.26480/sfna.01.2022.15.18

Bista, R., Ghimire, A., & Subedi, S. (2020). Phytochemicals and antioxidant activities of Aloe Vera (Aloe Barbadensis). *Journal of Nutritional Science and Healthy Diet*, *1*(1), 25–36.

Cascales, E. V., & García, J. M. R. (2020). Characteristics of the raw fruit, industrial pulp, and commercial jam elaborated with Spanish quince (*Cydonia oblonga* Miller). *Emirates Journal of Food and Agriculture*, *32*(8), 623–633. https://doi.org/10.9755/ejfa.2020.v32.i8.2140

Castro, J. C., Anjos, M. M. dos, Hoinatski, A., Klososki, S. J., Mikcha, J. M. G., Matshushita, M., … Abreu Filho, B. A. de. (2021). Dragon fruit (H*ylocereus undatus* Haw.) jam: Use full, development and characterization. *Research, Society and Development*, *10*(7), e6510716255. https://doi.org/10.33448/rsd-v10i7.16255

Chalchisa, T., Zegeye, A., Dereje, B., & Tolesa, Y. (2022). Effect of Sugar, pectin, and processing temperature on the qualities of pineapple jam. *International Journal of Fruit Science*, *22*(1), 711–724. https://doi.org/10.1080/15538362.2022.2113598

de Ridder, D., Kroese, F., Evers, C., Adriaanse, M., & Gillebaart, M. (2017). Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychology and Health*, *32*(8), 907–941. https://doi.org/10.1080/08870446.2017.1316849

Diabagate, H. M. F., Traore, S., Soro, D., Cisse, M., & Brou, K. (2020). Biochemical characterization and nutritional profile of jam and syrup from *Saba senegalensis* fruit in Côte d'Ivoire. *Journal of Food Research*, *9*(6), 67. https://doi.org/10.5539/jfr.v9n6p67

Dos Santos, B. A., Teixeira, F., Soares, J. M., Do Amaral, L. A., De Souza, G. H. O., De Almeida, T. da S. F., … Novello, D. (2020). Pineapple Jam physicochemical and sensory evaluation with added pineapple peel. *International Journal of Research - GRANTHAALAYAH*, *8*(7), 374–383. https://doi.org/10.29121/granthaalayah.v8.i7.2020.438

Dubey, A., Kumar, A., & Rao, P. S. (2021). Development and storage study of reduced calorie aloe vera (Aloe barbadensis Miller) based pineapple fruit jam. *Journal of Food Measurement and Characterization*, *15*(1), 961–975. https://doi.org/10.1007/s11694-020-00689-6

Gopukumar, S. T., Alexander, P., Jainamboo, M., & Praseetha, P. K. (2016). Phytochemical screening and FT-IR analysis of Ficus benghalensis fruits. *International Journal of Pharmacognosy and Phytochemical Research*, *8*(9), 1529-1534.

Handique, P., Deka, A. K., & Deka, D. C. (2020). Antioxidant properties and phenolic contents of traditional rice-based alcoholic beverages of Assam, India. *National Academy Science Letters*, *43*(6), 501–503. https://doi.org/10.1007/s40009-020-00903-5

Hasani, M., & Yazdanpanah, S. (2020). The effects of gum cordia on the physicochemical, textural, rheological, microstructural, and sensorial properties of apple jelly. *Journal of Food Quality*, *2020*. https://doi.org/10.1155/2020/8818960

Hęś, M., Dziedzic, K., Górecka, D., Jędrusek-Golińska, A.,

& Gujska, E. (2019). Aloe vera (L.) Webb.: Natural sources of antioxidants – A review. *Plant Foods for Human Nutrition*, *74*(3), 255–265. https://doi.org/10.1007/s11130-019-00747-5

Jayasree Radhakrishnan, A., & Venkatachalam, S. (2020). A holistic approach for microwave assisted solvent extraction of phenolic compounds from Ficus benghalensis fruits and its phytochemical profiling. *Journal of Food Process Engineering*, *43*(11). e13536. https://doi.org/10.1111/jfpe.13536

Kaur, S., Kaur, N., Aggarwal, P., & Grover, K. (2022). Sensory attributes, bioactive compounds, antioxidant activity and color values of jam and candy developed from Beetroot (*Beta vulgaris* L.). *Journal of Applied and Natural Science*, *14*(2), 459–468. https://doi.org/10.31018/jans.v14i2.3407

Kausar, T. (2020). Preparation and quality evaluation of ready to serve beverage (RTS) from orange juice and Aloe vera gel during storage. *Pure and Applied Biology*, *9*(1), 219–228. https://doi.org/10.19045/bspab.2020.90026

Khan, A., Shah, F. N., Zeb, Q., Zeeshan, M., Iqbal, H., & Noor, H. (2020). Preparation and development of fig fruit jam blended with different level of apple pulp. *Pakistan Journal of Scientific and Industrial Research Series B: Biological Sciences*, *63*(2), 105–112. https://doi.org/10.52763/pjsir.biol.sci.63.2.2020.105.112

Kmail, A., Asif, F., Rahman, R., Nisar, S., & Jilani, M. I. (2018). Banyan tree—the sacred medicinal tree with potential health and pharmacological benefits. *International Journal of Chemical and Biochemical Sciences*, *13*, 52-57.

Kouadio Atta, Gbocho Serge Elvis Ekissi, Claude Kouamé Ya, Bedel Jean Fagbohoun, & Lucien Patrice Kouamé. (2021). Physicochemical and sensory parameters of cashew apple jam (Anarcadium occidental L.) harvested in Bondoukou area (North East, Côte d'Ivoire). *Open Access Research Journal of Biology and Pharmacy*, *2*(2), 31–40. https://doi.org/10.53022/oarjbp.2021.2.2.0045

Kumar, R., Singh, A. K., Gupta, A., Bishayee, A., & Pandey, A. K. (2019). Therapeutic potential of Aloe vera—A miracle gift of nature. *Phytomedicine*, *60*, 152996. https://doi.org/10.1016/j.phymed.2019.152996

Mohd Naeem, M. N., Mohd Fairulnizal, M. N., Norhayati, M. K., Zaiton, A., Norliza, A. H., Wan Syuriahti, W. Z., … Rusidah, S. (2017). The nutritional composition of fruit jams in the Malaysian market. *Journal of the Saudi Society of Agricultural Sciences*, *16*(1), 89–96. https://doi.org/10.1016/j.jssas.2015.03.002

Montgomery, D. C. (2017). *Desgin And Analysis Of Experiments* (9th ed.). Arizona State University, USA: John Wiley & Sons, Inc.

Mori-mestanza, D., Perez-ruiz, D., Zuta-chamoli, V., Idrogo-vasquez, G., Barnard, A., Fernández, A., … Chavez-Quintana, S. G. (2022). Determination of the phenolic content, antioxidant activity and total anthocyanins of a beverage based on aloe vera and Jamaican sorrel (*Hibiscus sabdariffa*). *Research Square*, 1-12. https://doi.org/10.21203/rs.3.rs-1287358/v1

Munir, A. (2022). Editorial of International Journal of Pharmacy and Integrated Health Sciences. *International Journal of Pharmacy & Integrated Health Sciences*, *3*(1), 47–57. https://doi.org/10.56536/ijpihs.v3i1.27

Muñiz-Ramirez, A., Perez, R. M., Garcia, E., & Garcia, F. E. (2020). Antidiabetic Activity of Aloe vera Leaves. *Evidence-Based Complementary and Alternative Medicine*, Article ID 6371201, https://doi.org/10.1155/2020/6371201

Nafri, P., Singh, A. K., Sharma, A., & Sharma, I. (2021). Effect of storage condition on physiochemical and sensory properties of papaya jam. *Journal of Pharmacognosy and Phytochemistry*, *10*(2), 1296–1301. https://doi.org/10.22271/phyto.2021.v10.i2q.13990

Nguyen, Q. V., & Chuyen, H. Van. (2020). Processing of herbal tea from roselle (*Hibiscus sabdariffa* L.): Effects of drying temperature and brewing conditions on total soluble solid, phenolic content, antioxidant capacity and sensory quality. *Beverages*, *6*(1), 1–11. https://doi.org/10.3390/beverages6010002

Nookaratnam, G., Shivajirao, P. V., & Balasaheb, T. D. (2023). *Studies on effect of storage on quality characteristics of jaggery based mixed fruit jam*. *The Pharma Innovation Journal*, *12*(11), 1380–1390.

Nurerk, P., & Junden, S. (2021). Product development based sensory evaluation and physicochemical characterization of cashew apple bagasse jam and technology transfer to community. *Trends in Sciences*, *18*(22), 1–7. https://doi.org/10.48048/tis.2021.454

Ogori, A. F., Amove, J., Evi-Parker, P., Sardo, G., Okpala, C. O. R., Bono, G., & Korzeniowska, M. (2021). Functional and sensory properties of jam with different proportions of pineapple, cucumber, and Jatropha leaf. *Foods and Raw Materials*, *9*(1), 192–200. https://doi.org/10.21603/2308-4057-2021-1-192-200

Omolara, A., Nkechinyere, C., & Gbohunmi, L.-O. (2022). Comparism of composite jam produced from orange, apple and date powder with commercial jam with table sugar "comparism of composite jam produced from orange, apple and date powder with commercial jam with table. *Medicon Nutritional Health*, *1*(2), 12–19.

Pahari, A., Thapa, P., Thagunna, B., Kusma, R., & Kaur, J. (2022). Preparation and quality evaluation of underutilized unripe papaya candy. *Malaysian Journal of Halal Research*, *5*(2), 40–45. https://doi.org/10.2478/mjhr-2022-0006

Pérez-Herrera, A., Martínez-Gutiérrez, G. A., León-Martínez, F. M., & Sánchez-Medina, M. A. (2020a). The effect of the presence of seeds on the nutraceutical, sensory and rheological properties of Physalis spp. Fruits jam: A comparative analysis. *Food Chemistry*, *302*, 125141. https://doi.org/10.1016/j.foodchem.2019.125141

Pérez-Herrera, A., Martínez-Gutiérrez, G. A., León-

Martínez, F. M., & Sánchez-Medina, M. A. (2020b). The effect of the presence of seeds on the nutraceutical, sensory and rheological properties of Physalis spp. Fruits jam: A comparative analysis. *Food Chemistry*, *302*, 125141. https://doi.org/10.1016/j.foodchem.2019.125141

Purewal, S. S., Sandhu, K. S., Kaur, P., & Punia, S. (2022). Effect of processing on bioactive profile, minerals, and bitterness-causing compounds of Kinnow jam. *Journal of Food Processing and Preservation*, *46*(9), 1–10. https://doi.org/10.1111/jfpp.16629

Putnik, P., Lorenzo, J. M., Barba, F. J., Roohinejad, S., Jambrak, A. R., Granato, D., … Kovačević, D. B. (2018). Novel food processing and extraction technologies of high-added value compounds from plant materials. *Foods*, *7*(7), 1–16. https://doi.org/10.3390/foods7070106

Quesada Matos, R. L., Quesada González, O., Castellanos Parra, R., Cantos Macías, M. A., & Savilolo Josias, A. F. (2022). Processing of strawberry “Festival” to jam and determination of physical and physicochemical parameters. *Trends in Horticulture*, *6*(1), 1–9. https://doi.org/10.24294/th.v6i1.1836

Rafique, N., Mamoona, T., Ashraf, N., Hussain, S., Ahmed, F., Ali Shah, T., … Bourhia, M. (2023). Exploring the nutritional and sensory potential of karonda fruit: Physicochemical properties, jam production, and quality evaluation. *Food Science and Nutrition*, *11*(11), 6931–6944. https://doi.org/10.1002/fsn3.3619

Rana, M. S., Yeasmin, F., Khan, M. J., & Riad, M. H. (2021). Evaluation of quality characteristics and storage stability of mixed fruit jam. *Food Research*, *5*(1), 225–231. https://doi.org/10.26656/fr.2017.5(1).365

Reza, T., Zeynab, Y., Ali, A. G. H. (2012). Chemical composition and antioxidant properties of *Malva sylvestris* L. *Journal of Research in Agricultural Science*, *8*(1), 59-68.

Saeed Alkaltham, M., Musa Özcan, M., Uslu, N., Salamatullah, A. M., & Hayat, K. (2020). Effect of microwave and oven roasting methods on total phenol, antioxidant activity, phenolic compounds, and fatty acid compositions of coffee beans. *Journal of Food Processing and Preservation*, *44*(11), 1–9. https://doi.org/10.1111/jfpp.14874

Saha, B. K., & Ferdous, T. (2022). Evaluation of physico-chemical and nutritional properties and microbial analysis some Local Jam and Jelly in Bangladesh. *DUJASE*, *7*(1), 16-21.

Salam, Nafisah, Lydia, K., & Elizabeth, K. S. (2020). Production and acceptability of jam produced from pineapple, watermelon and apple blends. *EAS Journal of Nutrition and Food Sciences*, *2*(6), 321–325. https://doi.org/10.36349/easjnfs.2020.v02i06.003

Shagiwal, M., & Deen, B. (2022). Studies on development of ready-to-serve (RTS) beverage from strawberry (Fragaria ananassa Duch), ginger (Zingiber officinale Rosc) and aloe vera (Aloe barbadensis Miller) blend. *The Pharma Innovation Journal*, *11*(7), 2308–2317.

Sharma, R., Burang, G., Kumar, S., Sharma, Y. P., & Kumar, V. (2022). Optimization of apricot (*Prunus armeniaca* L.) blended Aloe vera (Aloe barbadensis M.) based low-calorie beverage functionally enriched with aonla juice (*Phyllanthus emblica* L.). *Journal of Food Science and Technology*, *59*(5), 2013–2024. https://doi.org/10.1007/s13197-021-05216-z

Solaberrieta, I., Jiménez, A., & Garrigós, M. C. (2022). Valorisation of Aloe Vera skin by-products to obtain bioactive compounds by microwave-assisted extraction: antioxidant activity and chemical composition. Antioxidants, *11*, 1058. https://doi.org/10.3390/antiox11061058

Sonawane, S. K., Gokhale, J. S., Mulla, M. Z., Kandu, V. R., & Patil, S. (2021). A comprehensive overview of functional and rheological properties of aloe vera and its application in foods. *Journal of Food Science and Technology*, *58*(4), 1217–1226. https://doi.org/10.1007/s13197-020-04661-6

Teixeira, F., dos Santos, B. A., Nunes, G., Soares, J. M., do Amaral, L. A., de Souza, G. H. O., … Novelle, D. (2020). Addition of Orange Peel in Orange Jam : *Molecules*, *25*(7), 1670.

Vijetha, P., Katari, N. K., Subbaiah, T., & Naik, K. M. (2021). Preparation of nutraceutical health drink using aloe vera as a base ingredient. *Journal of The Institution of Engineers (India): Series D*, *102*(2), 473–480. https://doi.org/10.1007/s40033-021-00273-2

Yadav, A., Gulia, G., & Yadav, B. (2020). Development of mulberry enriched fruit jam by replacing refined sugar with mulberry fruit. *International Journal of Scientific and Technology Research*, *9*(1), 4079–4083.

Ye, Q., Georges, N., & Selomulya, C. (2018). Microencapsulation of active ingredients in functional foods: From research stage to commercial food products. *Trends in Food Science and Technology*, *78*, 167–179. https://doi.org/10.1016/j.tifs.2018.05.025

Younas, N., Durrani, A. I., Rubab, S., Munawar, A., Batool, M., & Sheikh, A. (2021). Formulation and characterization of calcium- fortified jelly and its proximate composition and sensory analysis. *Journal of Oleo Science*, *70*(6), 849–854. https://doi.org/10.5650/jos.ess21051