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Characteristics and Quality of Guava Nectar Enriched with Gum Arabic as a Prebiotic Product

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GUAVA *(Psidium guajava L.)* contains a high concentration of vitamin C and carotenoids, making it perfect for nectar production. Gum arabic is a natural prebiotic fiber obtained from *Acacia* plant that is commonly used in meals and beverages. The goal of this study was to determine how adding various concentrations of gum arabic water extract (0, 1.5, 3.0, 4.5, and 6.0%) to guava nectar affects its shelf life, physical and chemical qualities, sensory evaluation, antimicrobial activity, and ability to produce a prebiotic nectar. Guava fruit had considerably more protein, fat, and ash levels than gum arabic (4.02, 3.3, and 2.21, respectively). The sensory evaluation revealed that guava nectar with 4.5% gum arabic water extract (sample 3) had much better sensory qualities than the other samples. The total phenolic and flavonoid content rose dramatically as the concentration of gum arabic increased. Guava nectar with 6.0% gum arabic (sample 4) had the highest total phenolic and flavonoid content, with 559.10 mg GAE/100g and 82.72 mg QE/100g, respectively, and the antioxidant activity reached 82.72%. Furthermore, the results showed that various samples had substantial antibacterial action against *Salmonella typhi*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, and *Candida albicans* as the gum arabic content increased. Additionally, gum arabic increases the viability of *Lactobacillus acidophilus* to 13.39 log CFU/mL. Furthermore, applying 1.5, 3.0, 4.5, and 6.0% gum arabic water extract to guava nectar produced a prebiotic nectar with better physicochemical properties and prolonged shelf life to six month. Therefore, the addition of 4.5% gum arabic water extract to guava nectar produces a functional product with potential health benefits, including enhanced antioxidant activity, improved antimicrobial efficacy, and support for probiotic activity.

Keywords: Gum arabic, Guava nectar, Prebiotic, Sensory evaluation, Physicochemical properties

Introduction

Guava (*Psidium guajava L.*), a tropical fruit known as a "super fruit," is highly recognized for its nutritious content, notably vitamins C and carotenoids, dietary fiber, and bioactive compounds such as flavonoids and phenolics (Shabbir et al., 2020). It has earned global notoriety for its distinct flavor and versatility in a variety of processed goods, including juices, jams, and jellies. Guava has long been used traditionally in medicine to control diverse ailments such as diabetes, hypertension, gastrointestinal disturbance, and rheumatism due to its antibacterial, antioxidant, and anti-inflammatory properties. Despite its high nutritional content, guava's susceptibility to decay needs the addition of items to extend its shelf life while preserving its health-benefiting features (Simran, 2023). According to Palachum et al. (2020), fermented guava pulp contains dietary fibers and other beneficial properties that can be processed into new products with increased nutritional value, improved gut health properties, and specific biological functionalities due to bioactive substances produced during fermentation.

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Gum arabic is a dried gummy biopolymer used to grow *Acacia senegal* plants (L.). Gum arabic is a non-thick fluid high in fiber. It is a water-soluble polysaccharide composed of sugars such as rhamnose, arabinose, and galactose, as well as highly branched complex arabinogalactan proteins. It also includes glucuronic acid, calcium, magnesium, and potassium (Mortensen et al., 2017). Gum arabic polysaccharides are permitted by European Food Safety Authority and utilized as a stabilizer and carrier in the food, cosmetic, and pharmaceutical sectors (Kaddam et al., 2017; Sharkawy & Alírio, 2024). Gum arabic, a possible prebiotic, is high in dietary fiber, indigestible in the stomach and small intestine, and consequently fermented in the large intestine by surrounding bacteria (Phillips and Phillips, 2011). As a result, it was discovered that gum arabic has prebiotic properties that can increase the number of *bifidobacteria* when fermented in the large intestine. Furthermore, it has been found that consuming 10 g of gum arabic per day might provide consumers with prebiotic benefits (Calame et al., 2008). Moreover, gum arabic has shown potential as a prebiotic and preserves prebiotic products. It has been used to treat mucous membranes and irritated surfaces because of its anti-inflammatory properties (Gibson et al., 2017 and Al Za'abi et al., 2018). Gum arabic and *Lactobacillus acidophilus*, alone or in synbiotic combinations, have beneficial effects. Synbiotics have a better and synergistic impact compared to prebiotics and probiotics alone (Bayoumi et al., 2024). Gum arabic has antioxidant properties, lowers blood cholesterol and triacylglycerol levels, and regulates inflammatory indicators. Beyond its prebiotic function, gum arabic has been demonstrated to have antibacterial activity against a variety of pathogens, including *Staphylococcus aureus* and *Bacillus subtilis,* making it a potentially useful ingredient for improving food safety and shelf life (Aloqbi, 2020). In certain investigations, the presence of gum arabic co-treated with *Lactobacillus plantarum* in milk products had an effect on harmful bacteria such as *Staphylococcus aureus* and *Bacillus subtilis* (Baien et al., 2020). Combining gum arabic with guava nectar gives a chance to create a nutritious, functional, and prebiotic beverage with long-term health advantages. Accordingly, this study aimed to investigate the impact of adding different concentrations of gum arabic to guava nectar on its physicochemical properties, sensory attributes, and antimicrobial activity to develop a prebiotic nectar formulation.

Materials and Methods

Materials

Gum arabic (*Acacia senegal*) powder was obtained from El-Nasr for Food Industries in Khartoum North. Egyptian guava fruits (*Psidium guajava*) of various sizes and shapes with thin and soft skin that ripens from green to yellow or white were obtained from the Horticulture Research Institute-Agriculture Research Center in Giza, Egypt. Bacterial cultures of *Salmonella typhi* (ATCC14028), *Escherichia coli* (RCMB010052), *Staphylococcus aureus* (ATCC6538), *Bacillus subtilis* (ATCC11778), *Candida albicans* (ATCC14053) and *Lactobacillus acidophilus* (ATCC4356) were obtained from the Faculty of Agriculture of Ain Shams University. All analytical-grade chemicals, reagents, and medium were bought from Sigma (USA).

Methods

Preparation of gum arabic

Gum arabic a 30 grams of resin were dissolved in 100 mL drinking water to make a 30% extract (weight/volume (w/v)). The solution was stirred using a magnetic stirrer (Wiess Gallenkamp, Leicestershire, UK) at 40 °C for 60 min, then filtered to remove any undissolved contaminants using cotton sheets, and stored in dry and clean bottles at -18 °C until analysis (Al-Juhaimi et al., 2012).

Proximate composition of guava fruit and gum arabic powder on dry weight

Protein, fat, and ash were determined using the by standard techniques (AOAC, 2019). Total carbohydrates were computed by subtracting 100 from the sum of protein, fat, and ash. Total dietary fiber, soluble dietary fiber, and insoluble dietary fiber were measured using the methods described by Asp et al. (1983).

Preparation of guava nectar

The guava fruits were cleaned, chopped, and the seeds were removed. The prepared guava was put in an electric mixer (Moulinex, Super Electric Blender, 700 Watt, LM207125, France), and then the drinkable water, sugar, and different ratios of 30% gum arabic water extracts (0, 1.5, 3.0, 4.5, and 6.0%) as shown in Table 1 were added and mixed well after adding 0.4 g of citric acid (Farhan and Rongen, 2014). The nectar was pasteurized at 90ºC for 30 seconds before being hot-filled into an amber glass bottle. It was then quickly cooled to room temperature using an ice water bath. All sampls were kept at 4°C for six months.

TABLE 1. Guava nectar ingredients and its samples with different concentrations of gum arabic.

Samples	Gum arabic extract* (mL)	Water (ml)	Guava fruits (gm)	Sugar (gm)
Control (guava nectar)	--	50	40	10
Sample 1	5	45	40	10
Sample 2	10	40	40	10
Sample 3	15	35	40	10
Sample 4	20	30	40	10

*Gum arabic extract 30% w/v

Sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic).

Sensory evaluation

Sensory evaluations were performed on guava nectar and with various concentrations of gum arabic addition by15 members from the Food Technology Research Institute- Agricultural Research Center. Each member received about 50 mL of nectar (from each concentration). Members were asked to score the samples on a hedonic scale of 1 (very poor) to 10 (excellent) for color, odor, flavor, taste, and overall acceptability using the approach developed by El-Gendy and El-Hadidy (2016).

Analysis of guava nectar and its samples with different concentrations of gum arabic

Total phenolics and flavonoids content

According to Singleton et al. (1999), the Folin-Ciocalteu reagent (mg gallic acid equivalent per 100 g) was used to calorimetrically assess the total phenolic contents of guava nectar and the samples with gum arabic water extract (30%). Using the methodology defined by Marinova et al. (2005), the total flavonoid compounds (mg quercetin equivalent per 100 g) were determined.

Antioxidant activity

The antioxidant activity of guava nectar and its samples with various gum arabic concentrations was investigated using the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) as a reagent, following the procedure published by Cuendet et al. (1997).

Antibacterial activity

The antibacterial activity of guava nectar and its samples with various gum arabic concentrations against *Salmonella typhi* (ATCC14028), *Escherichia coli* (RCMB010052), *Staphylococcus aureus* (ATCC6538), *Bacillus subtilis* (ATCC11778), and *Candida albicans* (ATCC14053) was evaluated using the agar well diffusion technique presented by (Ahmad and Beg 2001).

Lactobacillus acidophilus activity

Probiotic counts of *Lactobacillus acidophilus* (ATCC4356) were determined using Ertem & Çakmakçı (2018) methodology at 37°C ±1. Guava nectar and its samples with varied gum arabic concentrations were evaluated at zero, two, four, and six days.

Quality parameters of guava nectar and its samples with different concentrations of gum arabic during storage at 4ºC

Physicochemical characteristics

The pH of guava nectar and its samples at various concentrations of gum arabic were evaluated using a digital pH meter, according to AOAC (2019). The TSS value is obtained using a hand refractometer that operates on the principle of total refraction. A sample drop was put on the plate to read the TSS as ˚Brix (AOAC, 2019). The titratable acidity of guava nectar and its mixes at various gum arabic concentrations was measured using the method given by Ranganna (2014). The data were represented as mg citric acid per 100 grams. Duplicate readings were recorded.

Apparent viscosity

The apparent viscosity of guava nectar and its samples at various gum arabic concentrations was evaluated using a Brookfield Digital Rheometer, Model DVIII Ultra (SC4-21 spindle). The viscometer was set at 10 rpm. The nectar was put in a tiny sample adaptor, and a constant temperature water bath was utilized to maintain the appropriate temperature 25˚C±1 (Shahnawaz and Shiekh, 2011).

Color assay

Nectar samples were assessed in the L* (brightness), a* (red to green color), and b*

(yellow to blue color) systems with a Minolta Colorimeter CR-300 (Konica Minolta Business Technologies, Inc., Langenhagen Hannover, Germany) (AOAC, 2019).

Microbial analysis

The total number of colonies was determined using Morton (2001) methodology, which used the equation: Number of colony-forming units (cfu)/mL = average cfu/plate x dilution factor. The pour-plate method was used to detect the psychrophilic bacteria in nectar samples (AOAC, 2019).

Statistical analysis

Steel and Torrie (1980) used two-way analysis of variance (ANOVA) with SPSS version 19 to examine the data, which are reported as mean ± standard deviation. A significance level of $P < 0.05$ was used to identify statistically significant differences between samples.

Results and Discussion

Chemical composition of guava fruit and gum arabic powder (on dry weight)

Table 2 shows the approximate chemical composition of guava fruit and gum arabic powder based on dry weight. The results showed that guava fruit had much greater protein and fat and lower ash (4.02, 3.30, and 2.21%, respectively) than gum arabic, which had 2.43 and 0.30 in protein and fat, as well as higher ash (3.70%). Rosland et al. (2020) discovered that the ash percentage of gum arabic ranged from 3.6 to 3.9%, which was within the permissible range of less than 4% for food and pharmaceutical quality of gum arabic**.** At the same time, the protein, lipid, and carbohydrate levels varied from 2.0 to 2.4%, 0.1 to 0.6%, and 79.9 to 82.1%, respectively. These findings might be attributed to the chemical variation of gum arabic based on its place of origin, climate, harvest season, tree age, and processing conditions (Alkarib and Saeed, 2016). The findings for guava fruit were consistent with those of Ali et al. (2014) and Upadhyay et al. (2019), who discovered that carbohydrates constitute the major component of guava, with compositional differences noted among varieties. They also observed that guava fruit has a high ash and fiber content. Dietary fibers are carbohydrate polymers (Ahallil,2019);Phillips & Phillips, 2011). Gum arabic is a nondigestible dietary fiber that is mostly fermented by colonic intestinal bacteria (Capuano, 2017). Total dietary fibers, both soluble and insoluble, have been evaluated in guava fruit and gum arabic, and the findings are presented in the same table. The results showed that gum arabic had the highest percentage of total dietary fiber (75.68%), whereas soluble and insoluble dietary fiber were 19.36% and 56.32%, respectively. While guava fruit is a high source of dietary fiber, it contains 48.57% and 45.68% of total and insoluble dietary fiber, respectively, as well as the lowest amount of soluble dietary fiber (2.89%). The current study's dietary fiber level is consistent with the findings of Jiménez-Escrig et al. (2001), who showed that the insoluble, soluble, and total dietary fiber content in guava varied from 46.72 to 47.65%, 1.77 to 1.83%, and 48.55 to 49.42%, respectively.

Table 3 shows the mean scores of sensory evaluations of guava nectar and its samples with various concentrations of gum arabic, assessed for color, odor, flavor, taste, and overall acceptability on a hedonic scale. The results revealed that the guava nectar as a control had an average score of 8.07, 8.00, 7.93, and 7.82 for color, odor, flavor, and taste parameters, respectively, while total acceptability was 7.95. The findings show that samples 2 and 3 had the greatest scores for all sensory parameters, with no significant difference ($p \leq 0.05$) compared to control guava nectar and sample 1. Furthermore, regarding the taste characteristic, adding gum arabic at varying percentages to guava nectar resulted in nearly similar acceptability levels for 1, 2, and 3 samples. This might be owing to the odorless characteristics of gum arabic, which do not impact the product (Featherstone, 2015). This observation might be attributed to the tastelessness of gum arabic (Mohammed, 2015).

Meanwhile, nectar sample 4 (6.0%) recorded the lowest acceptability score compared to the other concentrations owing to undesirable textural (gel mouthfeel). This result might explan the nectar's lower acceptance score. Also, it demonstrated significant variations from the control. As a consequence of the findings, it was determined that adding 1.5, 3.0, and 4.5% water extract from gum arabic is appropriate and has no effect on the sensory attributes of guava nectar. Furthermore, the inclusion of 4.5% water extract from gum arabic (sample 3) results in high sensory attribute scores.

TABLE 2. Chemical composition of guava fruit and gum arabic powder (on dry weight).

Components %	Guava fruit	Gum arabic
Protein	4.02±2.56	2.43±0.06
Fat	3.30±0.87	0.30±0.45
Ash	2.21±1.45	3.70±0.17
Total carbohydrate	90.47±6.45	93.57±4.61
Total dietary fiber	48.57 ±2.54	75.68±4.35
Soluble dietary fiber	2.89±0.09	19.36±1.28
Insoluble dietary fiber	45.68±2.13	56.32±3.69

Sensory evaluation of guava nectar and its samples with different concentrations of gum arabic

TABLE 3. Sensory evaluation of guava nectar and its samples with different concentrations of gum arabic.

Samples	Parameters				
	Color (10)	Odor (10)	Flavor (10)	Taste (10)	Overall acceptability (10)
Control (guava nectar)	8.07 [b] ±0.31	8.00 [b] ±0.01	7.93 [c] ±0.03	7.82 [c] ±0.04	7.95 [c] ±0.02
Sample 1	8.87 [b] ±0.22	8.90 [b] ±0.02	8.89[b] ±0.01	8.73[b] ±0.02	8.85[b] ±0.02
Sample 2	9.00 [a] ±0.03	9.16 [a] ±0.01	9.05 [a] ±0.01	9.00 [a] ±0.03	9.05 [a] ±0.03
Sample 3	9.70 [a] ±0.26	9.50 [a] ±0.02	9.70 [a] ±0.01	9.50 [a] ±0.06	9.60 [a] ±0.01
Sample 4	7.02 [c] ±0.01	6.21 [c] ±0.01	5.11 [d] ±0.03	5.03 [d] ±0.01	5.85 [d] ±0.001

Gum arabic extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic).Data presented as mean ± SD different letter in the same column means significant differences at $p \leq 0.05$.

Total phenolics, flavonoids, and antioxidant activity of guava nectar and its samples with different concentrations of gum arabic

Table 4 shows the total phenolic and flavonoid content, as well as the antioxidant activity, of guava nectar and gum arabic water extract and their various samples. The total phenolic and flavonoid content rose dramatically as the concentration of gum arabic increased. Guava nectar with 6.0% gum arabic (sample 4) had the greatest total phenolics and flavonoids concentration, determining 559.10 mg GAE/100g and 82.72 mg QE/100g, respectively. Guava nectar's natural polyphenols and flavonoids concentration results in high antioxidant activity (68.97%). However, the DPPH scavenging activity rises with the addition of gum arabic, reaching 82.72% at a gum arabic content of 6.0% (sample 4). Gum arabic's exceptional free radical scavenging ability is attributable to its high quantity of bioactive components such as phenolics and flavonoids, as reported by ElSamoty (2021), who found total phenolics in gum arabic (40.67 mg/100 g). Guava fruits have comparatively strong antioxidant levels, as well as greater total phenol contents. The results indicate that guava has considerable primary antioxidant activity (Correˆa et al., 2011).

Antimicrobial activity of guava nectar and its samples with different concentrations of gum arabic

Table 5 shows the antimicrobial activity of guava nectar and its samples with gum arabic at various concentrations against Gram-positive, Gram-negative, and fungus strains. Guava nectar and its samples with gum arabic increasingly displayed an inhibitory effect against gram-negative bacteria as gum arabic increased, as *S. typhi* (20 to 26 mm) and *E. coli* (from 19 to 26 mm), compared to the control guava nectar, which was 17 and 16mm, respectively. Positive gram bacteria showed that nectar samples inhibited *S. aureus* (from 25 to 31 mm) and *B. subtilis* (from 17 to 25 mm). These values were greater than control nectar, which was 23mm and 14mm, respectively. Furthermore, *C. albicans* with various

nectar samples displayed diameters ranging from 18 to 21mm, in contrast to the control's 15mm. These results reveal that guava nectar samples at varying concentrations of gum arabic had the highest antibacterial impact, particularly against gram-positive bacteria rather than gram-negative bacteria. The observed results are consistent with Lawrence et al. (2015), who showed that the gum arabic extract exhibited high inhibitory action against *S. aureus, B. subtilis* (Gram-positive bacteria), *S. typhi, and E. coli* (Gram-negative bacteria). Gum arabic's antibacterial effect was attributable to its flavonoids and phenol levels. Furthermore, Farhana et al. (2017) state that guava extracts had stronger antibacterial activity against gram-positive bacteria than gram-negative bacteria due to phenolic components, making them efficient against the test pathogens. Flavonoids, due to their chemical structure, have various biological targets inside bacteria. For example, flavonoids interact with cell membranes to provide antibacterial action. Another potential interaction involves the creation of hydrogen bonds between hydrophilic flavonoids and the polar headgroups of cell membrane lipids (Xie et al., 2017).

Effect of guava nectar and its samples with different concentrations of gum arabic on Lactobacillus acidophilus activity at 37°C

Table 6 shows how guava nectar as a control and its samples with gum arabic at different concentrations affect the viability of *Lactobacillus acidophilus* as a probiotic bacterium at 2, 4, and 6 days. The results showed that progressively increasing the percentage of gum arabic in guava nectar boosted the viable counts of *Lactobacillus acidophilus* over a 6-day period. In comparison to the other samples, guava nectar (control) had the lowest log 3.01, 4.02, 6.01, and 8.00 CFU/mL throughout the six-day period. After 6 days, sample 4 (6.0%) had the highest viable counts of probiotic bacteria at log 13.39 CFU/mL, followed by samples 3, 2, and 1, which recorded log 11.76, 10.45, and 8.87 CFU/mL, respectively, indicating that samples 4 or 3 (6.0% and 4.5% gum arabic) had the strongest prebiotic effect. This impact can be ascribed to guava pulp's high nutritional content, which contains vitamins and minerals that promote the growth and survival of lactic acid bacteria (Slavin, 2013). Gum arabic is a soluble dietary fiber that acts as a prebiotic by selectively fermenting useful gut bacteria, increasing their development and activity (Elnour et al., 2023). In addition, the presence of gum arabic, which comprises approximately 85% prebiotic carbohydrates (Idris, 2017). Gum arabic's prebiotic characteristics encourage the growth and activity of probiotic bacteria in the colon, including *lactobacilli* and *bifidobacteria* (Cherbut et al., 2003).

TABLE 4. Total phenolics, flavonoids content, and antioxidants activity of guava nectar and its samples with different concentrations of gum arabic.

Samples	Parameters		
	Antioxidant activity % (DPPH)	Total phenolics (mg GAE/100g)	Total flavonoids (mg QE/100g)
Control (Guava nectar)	75.25 ^{e} ±0.12	51.70 ^{e} ±0.41	67.89 ^{e} ±0.34
Guava nectar with different gum arabic concentration (%)			
Sample 1	80.21 ^{d} ± 0.11	168.87 ^{d} ±0.33	69.73 ^{d} ±0.43
Sample 2	87.56 ^{c} ± 0.24	236.55 ^{c} ±0.24	72.13 ^{c} ±0.52
Sample 3	89.91 ^{b} ± 0.03	445.63 ^{b} ±0.11	76.74 ^{b} ±0.14
Sample 4	95.13 ^{a} ± 0.12	559.10 ^{a} ±0.08	82.72 ^{a} ±0.01

Gum arabic extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic). Data presented as mean ±SD; different letter in the same column mean significant differences at $p \leq 0.05$.

TABLE 5. Antimicrobial activity of guava nectar and its samples with different concentrations of gum arabic.

Samples	Strains inhibition zone (mm)				
	Gram-negative bacteria		Gram-positive bacteria		Fungi
	S. typhi	*E. coli*	*S. aureus*	*B. subtilis*	*C. albicans*
Control (guava nectar)	17.0	16.0	23.0	14.0	15.0
Sample 1	20.0	19.0	25.0	17.0	18.0
Sample 2	23.0	21.0	26.0	18.0	19.0
Sample 3	25.0	23.0	27.0	20.0	20.0
Sample 4	26.0	26.0	31.0	25.0	21.0

Gum arabic 30% extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic).

TABLE 6. Effect of guava nectar and its samples with different concentrations of gum arabic on lactic acid bacteria activity at 37°C.

Samples	*Lactobacillus acidophilus* (Log CFU Count/mL)			
	Zero time	2 day	4 day	6 day
Control (guava nectar)	3.01	4.02	6.01	8.00
Sample 1	5.00	7.01	8.01	8.87
Sample 2	6.01	9.12	10.22	10.45
Sample 3	6.17	9.90	11.29	11.76
Sample 4	6.37	10.25	11.98	13.39

Gum arabic 30% extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic).

Quality parameters of guava nectar and its samples with different concentrations of gum arabic during for six months of storage at 4ºC

Physicochemical characteristics

Total soluble solids

The total soluble solids of guava nectar as a control and its prebiotic samples with gum arabic at various amounts were measured throughout 6 months of storage, and the findings are shown in Table 7. The results show that following 6 months of storage. The highest TSS increase was recorded for sample 4 (6.0% gum arabic water extract), followed by sample 3 (4.5% gum arabic water extract). By the sixth month, the TSS values were 25.4° and 23.5° Brix, respectively. The control and samples showed a significant difference ($p < 0.05$) during storage. The results of this study are consistent with those reported by Singh and Sharma (2017), who discovered that increasing TSS is caused by the ongoing hydrolysis of polysaccharides into sugars, and lowering storage temperatures slows the rate of hydrolysis. Furthermore, these results correlate with the results of Parnanto et al. (2018) and Tuan et al. (2019), who observed that the addition of hydrocolloid (carboxymethyl cellulose and gum arabic) raised the TSS value in soursop velva *Annona muricata L.* and roselle juice. They discovered that carboxymethyl cellulose (CMC) is made up of linear, water-soluble polysaccharides, whereas gum arabic is made up of simple sugars or derivatives that may hydrolyze over time into smaller components. The hydrocolloid's composition, which includes linear and water-soluble polysaccharides as well as simple sugars, may cause a rise in TSS (Parnanto et al., 2018).

pH value

The same Table showed that after storage, the pH of the control (guava nectar) decreased dramatically from 3.5 at zero time to 2.90 by the fourth month and 2.23 by the sixth month. In contrast, the pH of samples 1, 2, 3, and 4 remained reasonably steady for the first four months at 3.31, 3.82, 4.18, and 4.54, respectively. Whereas, these samples slightly decreasing to 2.58, 2.92, 3.35, and 3.56 by the sixth month. This reveals that adding gum arabic caused an elevation in pH of nectar, particularly during the first four months of storage, compared to the control. This is consistent with Idris (2017), who observed that adding gum arabic increased the pH to (4.5) when compared to the control roselle extract, which had a pH of (2.6). Shukri et al. (2014) also reported that hydrocolloids such as guar gum and xanthan gum enhanced pH and lowered acidity in fermented glutinous rice ice cream, which they attribute to their acid-stabilizing capabilities. After six months of storage, a decrease in pH values was seen, particularly in the control sample, which may be caused by ascorbic acid degradation and pectic substance hydrolysis. Ascorbic acid degradation produces acidic compounds, while pectin hydrolysis generates free uronic acids, lowering pH (Pornrat et al., 2015).

Titratable acidity

Table 7 demonstrated significant differences in titratable acidity between guava nectar and its sample with gum arabic at various levels after 6 months of storage. Adding gum arabic did not result in significant changes in titratable acidity until the fourth month of storage, indicating that gum arabic does not contribute to the nectar's titratable acidity level. By the sixth month of storage, the titratable acidity had peaked for the control (1.20 mg citric acid/100 g). These readings surpassed the Egyptian standard's maximum of 0.8% for guava nectar (Egyptian Standards, 2005). Whereas sample 4 reached only (0.75 mg citric acid/100 g). These findings were consistent with Nwaokoro and Akanbi (2015), who discovered that adding hydrocolloids such as xanthan gum and carboxyl methylcellulose (CMC) to tomato carrot juice had no significant effect on the titratable acidity value. These findings might be attributed to pectic compounds in guava nectar that degrade with time, resulting in free uronic acids and increased acidity (Chen et al., 2023). Furthermore, ascorbic acid (vitamin C) in guava nectar can deteriorate during storage, resulting in organic acids that boost the nectar's acidity (Poonam et al., 2022). Although less prevalent in well-maintained nectar, microbial activity can convert carbohydrates to organic acids, raising acidity (Rashid et al., 2018).

Viscosity

Viscosity is an essential parameter that influences nectar quality and customer acceptability (Nayak et al., 2017). The viscosity of guava nectar and its samples with gum arabic at various concentrations after 6 months of storage at 4°C is shown in Fig. 1. The results showed that the control viscosity (guava nectar) and its samples gradually increased at various percentages of gum arabic during the storage period. The samples 1, 2, 3, and 4 had considerably higher viscosity, increasing from 110.89, 115.51, 115.75, and 120.32 cP to 152.85, 162.20, 181.55, and 230.90 cP, respectively, at the end of storage. The observed rise in viscosity during storage is consistent with Hashim and Ismail (2023), who stated that the viscosity of fruit nectar increases more slowly when stored at lower temperatures, which is attribute to the decomposition of pectic components. Over time, the breakdown of pectin compounds changes the nectar's consistency, resulting in increased viscosity. The increase in nectar viscosity in the samples containing gum arabic could be attributed to the structure of gum arabic, which has long branches with bulky arrangements capable of creating hydrogen bonds with water molecules, causing an increase in hydrodynamic volume and thus forming a viscous solution (Akkarachaneeyakorn and Tinrat, 2015). These data reveal that adding gum arabic greatly increased the viscosity of the nectar, with a larger rise than the control (guava nectar).

Color changes

Figure 2 displays the color variations of guava nectar and prebiotic guava nectar samples throughout a six-month storage period at 4°C. The results indicated that the L* value (lightness) of the control (guava nectar) decreased from 54.43 at the beginning to 45.1 by the sixth month, showing that the nectar gradually darkened. Similarly, the samples 1, 2, 3, and 4 (1.5, 3.0, 4.5, and 6.0% gum arabic) showed a modest drop in L* value from 54.24, 54.25, 54.64, and 55.64 to 52.36, 52.22, 52.14, and 53.14, respectively. The a* value (redness) increased dramatically in control from 11.45 to 14.32 and samples 1, 2, 3, and 4 increasing from 11.45, 11.49, 11.51, and 11.52 to 13.79, 13.26, 12.73, and 12.20, respectively, at the end of storage. The b* value (yellowness) also increased

slightly; the control climbed from 36.22 to 40.98, while the various samples increased from 36.46, 36.70, 36.94, and 37.19 to 40.24, 39.50, 38.76, and 38.02, respectively. These changes indicate a minor improvement in the yellow and red colors of the nectar over the storage period. These findings are consistent with Krumreich et al. (2018), who found a significant drop in L* values for guava nectar treatments, including xanthan at zero time and at the end of storage (day 180). The rise in redness and yellowness is most likely caused by the presence of carotenoids in nectar, which contribute to color changes over time. Furthermore, Bujanga et al. (2016) found that the drop in L* value and rise in a* and b* values during storage correspond to the darkening or browning of the pink guava juice. This can be induced by enzyme activity, non-enzyme browning (for example, the Maillard process), or pigment degradation. The Maillard process and caramelization occur between amino acids and reducing sugars, generating brown pigments that accentuate the red and yellow colors in the juice.

Microbiological evaluation

The microbiological evaluation of guava nectar and its samples with various concentrations of gum arabic over 6 months of storage at 4°C revealed the findings shown in Table 8. The findings showed that the total viable bacteria counts during storage differed considerably between the control (guava nectar) and the various samples. After 6 months of storage, the control had the greatest levels of total bacterial count (log 7.36 cfu/mL) and yeast/mold (log 5.51 cfu/mL). These levels lead to rejecting the control after 4 months because it exceeded permitted microbiological limits (Egyptian Standards, 2005). In contrast, the various samples (1.5, 3.0, 4.5, and 6.0%) exhibited much reduced microbial contamination after 6 months, with bacterial counts, yeast, and molds in samples 3 and 4 reaching log 3.50, 1.84, 2.95, and 1.30 CFU/mL, respectively, after 6 months of storage. This implies that the use of gum arabic effectively suppressed microbial development during storage.

TABLE 7. Physicochemical characteristics of guava nectar and its samples with different concentrations of gum arabic during 6 months of storage at 4 ºC.

Samples	Zero time	2 Month	4 Month	6 Month
		Total Soluble Solids (TSS) °Brix		
Control (guava nectar)	13.5 ^{eD} ±0.72	13.8 ^{eC} ±0.24	^{eB} ±0.65 14.1	14.5 ^{eA} ±0.62
Sample 1	14.0 ^{dD} ±0.81	16.5 ^{dC} ±0.45	17.5 ^{dB} ±0.28	18.8 ^{dA} ±0.53
Sample 2	14.5 ^{cD} ±0.84	18.4 ^{cC} ±0.52	19.4 ^{cB} ±0.35	20.1 ^{cA} ±0.73
Sample 3	15.0 ^{bD} ±0.92	20.6 ^{bC} ±0.76	21.6 ^{bB} ±0.42	23.5 ^{bA} ±0.48
Sample 4	15.5 ^{aD} ±0.94	23.3 ^{aC} ±0.95	23.8 ^{aB} ±0.21	25.4 ^{aA} ±0.89
		pH		
Control (guava nectar)	^{eA} ±0.01 3.50	3.32 ^{eB} ±0.04	2.90 ^{eC} ±0.01	2.23 ^{eD} ±0.03
Sample 1	3.70 ^{dA} ±0.02	3.74 ^{dA} ±0.02	3.31 ^{dB} ±0.03	2.58 ^{dC} ±0.04
Sample 2	3.90 ^{cB} ±0.04	4.16 ^{cA} ±0.03	3.82 ^{cC} ±0.04	2.92 ^{cD} ±0.03
Sample 3	^{bB} ±0.08 4.20	^{bA} ±0.04 4.41	4.18 ^{bC} ±0.03	3.35 ^{bD} ±0.02
Sample 4	4.50 ^{aB} ±0.05	^{aA} ±0.005 4.60	4.54 ^{aB} ±0.04	3.56 ^{aC} ±0.07
		Titratable acidity (mg citric acid/ 100 grams)		
Control (guava nectar)	0.42 ^{aD} ±0.07	0.66 ^{aC} ±0.09	0.95 ^{aB} ±0.03	1.20 ^{aA} ±0.01
Sample 1	0.42 ^{aD} ±0.01	0.64 ^{aC} ±0.05	0.85 ^{bB} ±0.02	0.95 ^{bA} ±0.05
Sample 2	0.41 ^{aC} ±0.01	0.60 ^{aB} ±0.04	0.80 ^{bA} ±0.05	0.85 ^{cA} ±0.07
Sample 3	0.41 ^{aD} ±0.02	0.55 ^{bC} ±0.04	0.62 ^{cB} ±0.03	0.80 ^{cA} ±0.03
Sample 4	0.41 ^{aC} ±0.02	0.50 ^{bB} ±0.04	0.55 ^{dB} ±0.02	0.75 ^{dA} ±0.06

Gum arabic 30% extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic).. Data presented as mean ±SD; different letter in the same colmn means significant differences at $p \leq 0.05$. Capital letters indicate significant differences for storage time, while lowercase letters indicate significant differences between samples

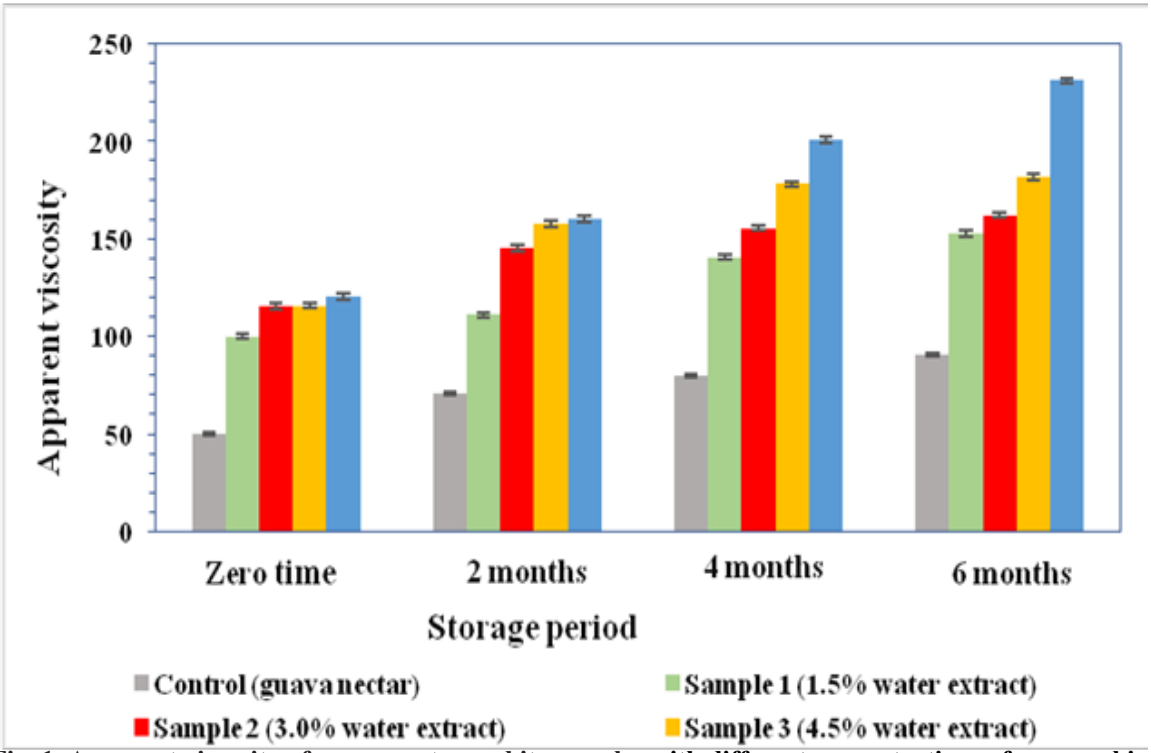

Fig. 1. Apparent viscosity of guava nectar and its samples with different concentrations of gum arabic during 6 months of storage at 4 ºC.

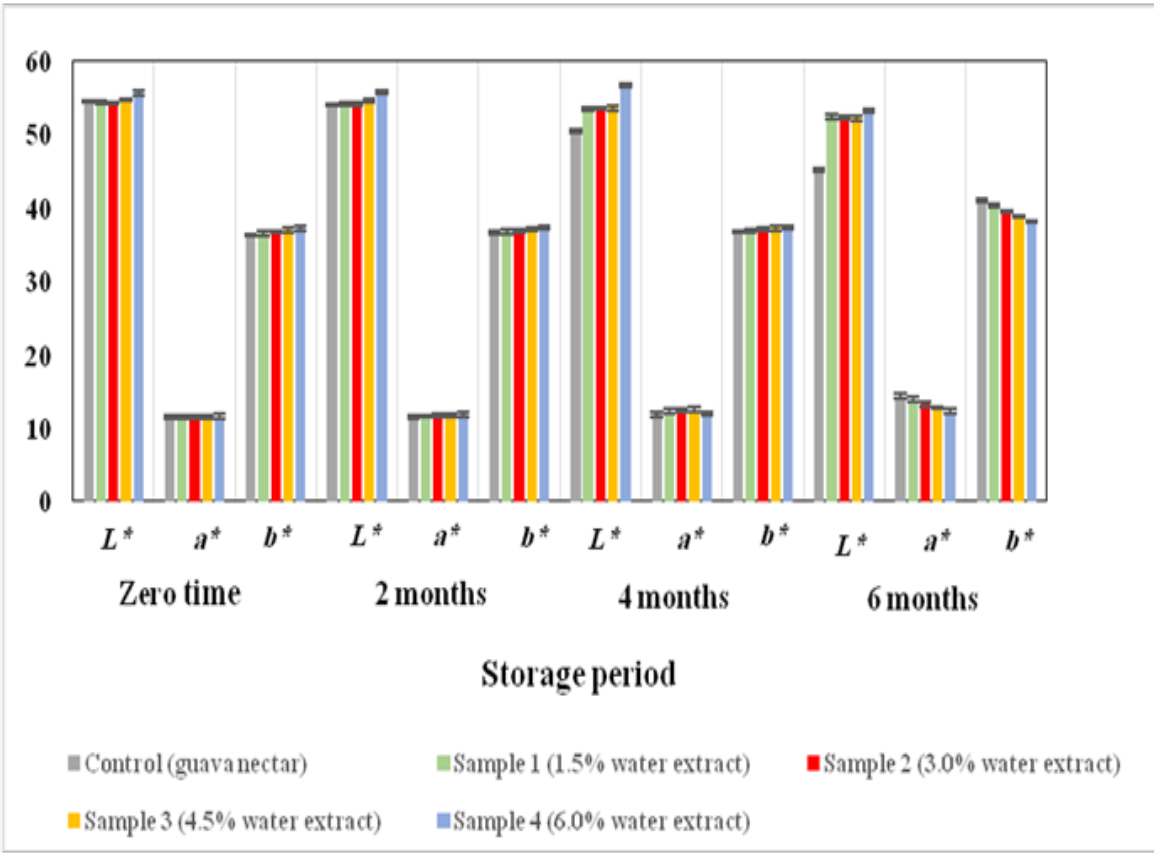

Fig. 2. Color changes of guava nectar and its samples with different concentrations of gum arabic during 6 months of storage at 4 ºC.

TABLE 8. Microbiological evaluation of guava nectar and its samples with different concentrations of gum arabic during 6 months of storage at 4 ºC.

Samples	(Log CFU Count/mL)							
	Zero time		2 months		4 months		6 months	
	TBC	Y&M	TBC	Y&M	TBC	Y&M	TBC	Y&M
Control (guava nectar)	ND	ND	4.90	1.95	5.44	3.90	7.36	5.51
Sample 1	ND	ND	3.74	1.47	4.98	3.04	6.23	3.87
Sample 2	ND	ND	2.30	1.30	2.95	2.17	4.39	3.20
Sample 3	ND	ND	ND	ND	2.65	1.48	3.50	1.84
Sample 4	ND	ND	ND	ND	ND	ND	2.95	1.30
	Psychrophilic bacteria							
Control (guava nectar)	ND		ND		1.48		2.60	
Sample 1	ND		ND		1.30		2.00	
Sample 2	ND		ND		1.00		1.90	
Sample 3	ND		ND		ND		1.60	
Sample 4	ND		ND		ND		1.30	

Gum arabic 30% extract (weight/volume (w/v)), sample 1 (1.5% gum arabic), sample 2 (3.0% gum arabic), sample 3 (4.5% gum arabic) and sample 4 (6.0% gum arabic). TBC: Total bacterial count, Y&M: yeast and mold.

Gum arabic's antibacterial capabilities are likely to have contributed to the lower microbial counts reported in the 3 and 4 samples. Shima et al. (2019) demonstrated that gum arabic improves antibacterial action, hence enhancing pathogen killing. Other investigations on fruits, such as persimmon, choke anan mango, and ashwina mango, found that gum arabic increased storage life by decreasing the activity of microbial enzymes responsible for cell wall disintegration (Mshraky et al., 2016 and Hasan et al., 2020)**.**

The same table shows that samples 3 and 4 inhibit the development of psychrophilic bacteria Incorporating gum arabic into fruit juices has been shown to enhance both their quality and safety. A study on papaya fruits covered with gum arabic revealed a reduction in bacteria counts during cold storage (Addai et al., 2013). A research of turbid mango juice found that adding a gum arabic-vanillin emulsion increased antioxidant capacity and microbiological safety, significantly increasing the juice's shelf life (Daisy et al., 2020). These findings indicate that gum arabic can play an important role in maintaining fruit quality and suppressing microbial development during storage. Samples 3 and 4 had acceptable microbiological levels, while sample 4 was assessed as sensory unsatisfactory.

Conclusion

This study investigated the effects of enriching guava nectar with gum arabic water extract at various concentrations (1.5, 3.0, 4.5, and 6.0%) on sensory attributes, physicochemical characteristics, and antimicrobial activity in order to improve shelf life and nutritional value. The results showed that gum arabic considerably increased antioxidant activity, with greater flavonoid and phenolic content as gum arabic concentrations increased. The investigation found that the sample 3 (4.5% gum arabic) scored the highest across all sensory and quality parameters. The various guava nectar samples showed high antibacterial efficacy against the pathogens examined. Additionally, gum arabic increased the viability of probiotic bacteria (*Lactobacillus acidophilus*). The research study revealed that replacing 4.5% gum arabic water extract for guava juice improves its physicochemical qualities, extends its shelf life, and boosts probiotic culture, transforming it into a viable prebiotic nectar with several health advantages.

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