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Impact of different pectin levels and banana varieties on the nutritional and sensory properties of banana jam

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Abstract

Banana is a significant crop worldwide, and it is prone to spoilage after ripening. Processing bananas into food products reduces their post-harvest losses and promotes food security. Jam is a popular banana product, and its preparation is influenced by several factors, including pectin content and different banana varieties. The current research aimed to assess the nutritional and sensory properties of banana jam developed from Cavendish dwarf (local variety) and Indial long (hybrid variety) and treated with three different levels of pectin i.e., 5, 10, and 15 g kg^{-1}. The results revealed that 15 g kg^{-1} pectin levels resulted in a better nutritional profile and sensory attributes, with 0.72% ash, 61.59% TSS, 4.28 pH, 13.84 mg 100 g^{-1} vitamin C, 4.34% protein, 40.10% carbohydrate, 1.34% fat, 0.50% crude fiber, 0.32% titratable acidity, 78.13 mg 100 g^{-1} potassium, 0.82 mg 100 g^{-1} iron, 1.56 mg 100 g^{-1} calcium, 1.36 mg 100 g^{-1} magnesium, 29.62 mg 100 g^{-1} sodium, and sensory scores of 7.87 for color, 7.78 for flavor, 7.85 for texture, and 7.92 for overall acceptability. This was followed by the 10 g and 5 g kg^{-1} pectin levels. Similarly, the results of varieties showed the Indial long variety to have superior nutritional and sensory qualities compared to the Cavendish dwarf variety, with 0.86% ash, 54.20% TSS, 4.23 pH, 12.78 mg 100 g^{-1} vitamin C, 4.56% protein, 39.29% carbohydrate, 1.15% fat, 0.37% crude fiber, 0.33% titratable acidity, 78.01 mg 100 g^{-1} potassium, 0.81 mg 100 g^{-1} iron, 1.62 mg 100 g^{-1} calcium, 1.27 mg 100 g^{-1} magnesium, and 29.67 mg 100 g^{-1} sodium. Its sensory scores were 7.93 for color, 7.83 for flavor, 7.90 for texture, and 7.96 for overall acceptability. It can be concluded that banana jam prepared with a pectin ratio of 15 g kg^{-1} has better nutritional and sensory characteristics. The results reflected that the Indial long variety was more suitable for banana jam production as compared to the Cavendish dwarf variety.

Keywords: Banana jam, Banana varieties, Nutritional evaluation, Pectin levels, Sensory attributes

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Introduction

Banana (*Musa sp.*, family Musaceae) is one of the most significant crops in the world after wheat, rice, and maize, both in terms of area cultivated and production (FAO, 2020). It accounts for about 16% of the total fruits produced worldwide (Pathak et al., 2017). It is also a significant fruit crop in Pakistan with international economic value and known to be a highly nutritious fruit that is high in phytochemicals, unsaturated fatty acids, and sterols, with a medium-sized banana containing 6 grams of fiber (Netshiheni et al., 2019; Shah et al., 2020). It is high in carbohydrates, minerals (potassium and calcium), and vitamins (A, B_1, B_2, and C), and it gives the body a lot of energy (100 calories per 100 grams) (Ahmed et al., 2017a). In addition, ascorbic acid, tocopherol, beta carotene, phenolic groups, dopamine, and gallocatechin are other antioxidants found in bananas (Shian and Abdullah, 2012). The chemical makeup of bananas varies depending on the stage of maturation. The starch content of bananas reduces as they age and ripen because about 80% of the starch is converted to soluble sugars such as glucose, fructose, and sucrose, increasing the soluble sugars to 19% (Palijama et al., 2020). Bananas are perishable in nature and are prone to deteriorate quickly, especially after they have ripened. After being harvested, the banana loses water content, which makes it vulnerable to shriveling, weight loss, insect infestations, and attack of organisms that cause rot (Esguerra et al., 2018).

Ripe, mature banana fruits undergo industrial processing to develop different products such as puree, juice, jam, jelly, etc. (Shandilya and Siddiq, 2020). To develop high-quality jam, the fruit must be ripe, free of rotting indications, and have enough pectin and acid (Dahlan, 2020). Extending shelf life, promoting consumer food diversity, and ensuring food security are all benefits of processing bananas into food products. Processing can also assist in creating jobs and improve market efficiency, especially for small and local firms (Singh et al., 2018). The preparation of jam is the most effective method for preserving perishable fruits. In many parts of the world, it is an old preservation method. Perishable fruits have long been preserved in jams so that they can be consumed

during the off-season. Jams have a healthy nutrient profile with significant amounts of sugar, fiber, minerals, and amino acids, as well as zero fat and cholesterol (Bekele et al., 2020). Jam is a semi-solid food product that is developed by heating fruit or vegetable pulp along with sugar, citric acid, pectin, and other ingredients until it has the right consistency. It is mostly served with bread for breakfast or in desserts such as cakes and pastries (Ahmed et al., 2017b). Jam-making is influenced by several factors, including the fruit's quality and the amounts of pectin, sugar, pH, and total soluble solids (Aziz et al., 2020). In the process of jam-making, pectin acts as a gelling agent and food hydrocolloid, where both hydrophilic and hydrophobic interactions occur (Shinwari and Rao, 2020).

Pectin is a refined polysaccharide usually extracted from citrus fruit peels. It acts as a crucial thickening agent, influencing the texture and flow behavior of the final product (Javanmard and Endan, 2010). Widely utilized in the food and pharmaceutical industries, pectin serves as a gelling, thickening, and stabilizing agent, ensuring the desired texture and moisture content in products (Brejnholt, 2010). It is recognized as safe by regulatory bodies such as the FAO/WHO Joint Expert Committee on Food Additives (JECFA), the European Union, and the FDA in the United States and is generally recognized as safe (GRAS) (Endreb and Christensen, 2009). Modifications in pectin levels not only affect the textural qualities but also have implications for the nutritional value of the jam, as pectin contributes to dietary fiber and can modify the banana's flavor profile. The selection of the banana variety further complicates this relationship as different cultivars bring diverse flavors, sugar compositions, and acid contents, which in combination with pectin can yield varied nutritional and sensorial characteristics. Understanding the optimal pectin ratios for each banana variety can lead to enhanced nutritional and sensory attributes offering both culinary innovation and nutritional advancement in jam manufacturing. Thus, in the present study, two varieties of banana fruits (i.e., Cavendish dwarf (local variety) and Indial long (hybrid variety)) were utilized to prepare banana jam by adding different levels of pectin i.e., 5, 10, and 15g kg^{-1} to assess its impact on the nutritional and sensory characteristics of the jam.

Materials and Methods

Sample collection

Mature and ripe banana fruits i.e., Cavendish dwarf (local variety) and Indial long (hybrid variety) were purchased from Khisana Mori and Saleh Makrani villages near Tandojam City, Pakistan. Other ingredients i.e., sugar, pectin, and citric acid were purchased from the local market.

Preparation of jam

The preparation of banana jam was done as depicted in Fig. 1. Both varieties of banana fruits were properly washed with tap water followed by distilled water to remove dirt and dust. After washing the banana fruits from both banana varieties were separated into 06 different lots (1 kg each) to develop jam with different proportions of pectin. The skin of the banana fruits was peeled, cut into small pieces, and boiled in water at 90ºC till the pieces became soft. After boiling, the banana pieces were crushed and 350g of sugar and 4g of citric acid were added to maintain the pH in the desired range. The mixtures were continuously stirred at 80ºC. In the end, pectin (05, 10, and 15 grams) was added to the hot pulps until the homogenous mixtures were accomplished. Then the samples were packed in glass bottles and stored at room temperature to further analyze their nutritional and sensorial characteristics.

Nutritional analysis

The determination of ash, total soluble solids (TSS), pH value, protein, total carbohydrates, fat, crude fiber, and titratable acidity was carried out by following the standard methods of AOAC (2016). Iron, calcium, magnesium, and sodium were determined using Atomic Absorption Spectrophotometer, and potassium was determined using flame photometry by the procedures outlined in AOAC (2016).

Sensory analysis

The sensory evaluation of banana jam was carried out by the panel of twenty judges (Professors and senior students of IFST) to measure the degree of preference among the different treatments for various attributes i.e., color, flavor, texture, and overall acceptability by using a nine-point hedonic scale as described by Iwe, (2002).

Statistical analysis

A two-way analysis of variance (ANOVA) was performed on the recorded data to determine the impact of varieties and pectin levels on the nutritional and sensorial characteristics of banana jam as described by Steel et al. (1997). Three replications were analyzed for each test. To evaluate statistically significant variations between means at the 5% level of probability, Duncan's Multiple Range test was used (Duncan, 1952).

Results and Discussion

Nutritional analysis

The average nutritional properties of banana jam prepared from Cavendish dwarf (local variety) and Indial long (hybrid variety) treated with different pectin levels i.e., 5, 10, and 15g kg^{-1} were significantly different ($P<0.05$). The mean values for the nutritional composition of banana jams are presented in Tables 1, 2, and 3.

Ash (%)

Any food commodity's ash content is equal to its entire mineral content. The ash of banana jam was maximum (0.72%) in 15 g pectin levels, followed by 10g pectin levels with 0.69% average ash, while the minimum ash of

0.42% was observed in 5 g pectin levels (Table 1). Similarly, Chalchisa et al. (2022) observed an increased trend of ash content with the increasing ratio of sugar and pectin. The results further showed that the ash of the banana variety "Indial long (Hybrid variety)" was greater (0.86%) than the variety "Cavendish dwarf (local variety)" (0.35%). The interactive effect of pectin level at 10g × variety "Indial long (Hybrid variety)" resulted in maximum ash (1.05%) and the lowest ash (0.28%) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". Overall, the observed findings suggest that both pectin level and banana variety significantly influence the ash content of banana jam. Similarly, Muresan et al. (2014) also observed a similar ash content in the range of between 0.63 to 0.57% in banana fruit jams. In a similar study by Awolu et al. (2018) the ash content in jam prepared by the blends of banana, pineapple, and watermelon ranged from 0.27 to 0.38%.

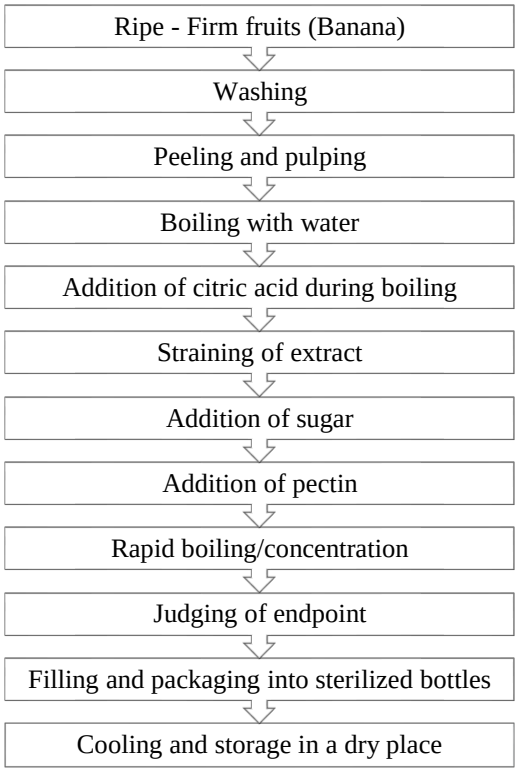

Fig. 1 Flow diagram for processing of banana-to-banana jam

Total soluble solids (°Brix)

Total Soluble Solids (TSS) of banana jams were maximum (61.59 °Brix) in 15g pectin levels, followed by 10g pectin levels with 49.98 °Brix, while the minimum level of total soluble solids 47.36 °Brix was observed in 5g pectin levels (Table 1). Pectin aids in jam gelation, and higher levels concentrate the fruit sugars by reducing water retention. Similarly, an increased trend of total soluble solids as degree brix was observed in pineapple jam treated with different ratios of sugar and pectin (Chalchisa et al., 2022). The results further showed that the total soluble solids of the banana variety "Indial long (Hybrid variety)" were greater (54.20 °Brix) than the variety "Cavendish dwarf (local variety)" (51.76 °Brix). The interactive effect of pectin level at 15g × variety "Cavendish dwarf (local variety)" resulted in maximum total soluble solids (62.50 °Brix) and the lowest total soluble solids (44.76 °Brix) was recorded in 10g pectin level × variety "Cavendish dwarf (local variety)". The observed results align with the findings of Fibrianto et al. (2020) who also observed TSS content in the range of 38.50 to 57.57 °Brix in banana jams.

pH value

The pH value of banana jam was maximum (4.28) in 15 g pectin levels and 10g pectin levels, followed by 5g pectin levels with a value of 3.95 (Table 1). Chalchisa et al. (2022) found the same increasing trend of pH with the increase of sugar and pectin concentrations in pineapple jam. Whereas Afoakwa et al. (2006) did not find a significant difference ($p<0.05$) in pH in jam treated with pectin. The results further showed that the pH value of the banana variety "Indial long (Hybrid variety)" was greater (4.23) than the variety "Cavendish dwarf (local variety)" (4.10). The interactive effect of pectin level at 15g × variety "Cavendish dwarf (local variety)" resulted in a maximum pH value (4.48), and the lowest pH value (3.69) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". The pH of banana jam was influenced by both factors i.e., pectin levels and the specific banana variety used. Generally, the pH value of fruit jams ranges from 3.5 to 4.5. The acidity of jam is important for several reasons. It helps to preserve the jam by preventing the growth of bacteria, gives jam its characteristic flavor, and helps to create a gel-like texture. The observed results relate with the findings of

Azira et al. (2021) who also observed pH in the range of between 4.40 to 3.96 in banana jam. He also observed a decrease in the pH value during storage. A similar study conducted by Fibrianto et al. (2020) also recorded similar results ranging from 4.97 to 4.57 in the pH of banana jam.

Table 1 Nutritional analysis of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Ash %			TSS %			pH value		
	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	0.28	0.56	0.42b	48.01	46.71	47.36c	3.69	4.21	3.95b
T_2=(10g)	0.33	1.05	0.69a	44.76	55.21	49.98b	4.15	4.42	4.28a
T_3=(15g)	0.46	0.98	0.72a	62.50	60.69	61.59a	4.48	4.08	4.28a
Mean	0.35b	0.86a		51.76b	54.20a		4.10b	4.23a	
SE±	0.1585			0.6185			0.0479		
LSD 0.05	0.3531			1.3781			0.1066		

Varieties: CD = Cavendish Dwarf (Local variety); IL = Indial Long (Hybrid variety)

Vitamin C (mg 100 g^{-1})

The vitamin C content of the banana jam was maximum (12.33 mg 100 g^{-1}) in 15g pectin levels followed by 10g pectin levels with 11.28 mg 100g^{-1}, while the minimum vitamin C of 10.78 mg 100 g^{-1} was found in 5g pectin levels (Table 2). A similar trend of increased vitamin C content was found in lemon pectin-based jam by Sulieman et al. (2013). The results further showed that the vitamin C of the banana variety "Cavendish dwarf (local variety)" was greater (11.57 mg 100 g^{-1}) than the variety "Indial long (Hybrid variety)" (11.35 mg 100 g^{-1}). The interactive effect of pectin level at 15g × variety "Cavendish dwarf (local variety)" resulted in maximum vitamin C (13.16 mg 100 g^{-1}), and lowest vitamin C (9.4 mg 100 g^{-1}) was recorded in the interaction of 5g pectin levels × variety "Indial long (Hybrid variety)". The vitamin C content of fruit jams is generally lower than fresh fruits because it reduces during the cooking process used to make jam. However, in general, most fruit jams contain between 5 and 25 mg of vitamin C per 100 grams. The observed results align with the findings of Awolu et al. (2018) who also observed vitamin C in a range of between 3.68 to 10.31 mg 100 g^{-1} from blends of banana, pineapple, and watermelon pulp jam.

Protein (%)

The protein content of banana jam was maximum (4.34%) at 15g pectin levels, followed by 10g pectin levels at 4.20%, while the minimum protein of 3.97% was recorded in 5g pectin levels (Table 2). These results indicate that higher pectin levels (15 g) showed slightly higher protein content compared to lower levels. This could be due to pectin interacting with protein molecules, potentially affecting their solubility or extraction during jam-making. The results further showed that the protein of the banana variety "Indial long (Hybrid variety)" was greater (4.56%) than the variety "Cavendish dwarf (local variety)" (3.78%). The interactive effect of pectin level at 10g × variety "Indial long (Hybrid variety)" resulted in maximum protein (4.72%), and lowest protein (3.37%) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". The observed results are in line with the findings of Awolu et al. (2018) who also observed protein content in the range of 0.26 to 8.58% from blends of banana, pineapple, and watermelon pulp jam.

Carbohydrate (%)

The carbohydrate content of banana jam was maximum (40.10%) at 15 g pectin levels, followed by 10g pectin levels at 34.87%, while the minimum carbohydrates of 33.51% were recorded at 5g pectin levels (Table 2). Pectin is a natural thickener that binds with water and sugar to create the gel texture of jam. Higher pectin levels likely require more sugar for proper consistency, leading to increased carbohydrate content. Similarly, Gurg et al. (2019) also observed an increased carbohydrate content in jams prepared from apple and jamun pulp. The results further showed that the total carbohydrates of the banana variety "Indial long (Hybrid variety)" were greater (39.29%) than the variety "Cavendish dwarf (local variety)" (33.04%). The interactive effect of pectin level at 10g × variety "Indial long (Hybrid variety)" resulted in maximum carbohydrates (42.72%), and lowest carbohydrates (29.77%) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". Bananas are naturally high in carbohydrates and when cooked down to make jam, the carbohydrates are concentrated, resulting in a high-carb product.

Table 2 Nutritional analysis of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Vitamin C (mg 100 g^{-1})			Protein %			Carbohydrates %		
	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	9.75	10.31	10.03c	3.37	4.58	3.97b	29.77	37.25	33.51b
T_2=(10g)	12.16	13.50	12.83b	3.69	4.72	4.20ab	31.85	37.90	34.87b
T_3=(15g)	13.16	14.52	13.84a	4.28	4.40	4.34a	37.49	42.72	40.10a
Mean	11.69a	12.78a		3.78b	4.56a		33.04b	39.29a	
SE±	1.5854			0.1658			2.5824		
LSD 0.05	3.5324			0.3694			5.7541		

Fat (%)

The content of fat in the banana jam was maximum (1.34%) at 15g pectin levels, followed by pectin levels 10g with 1.02%, while the minimum fat of 0.99% was noted at 5 g pectin levels (Table 3). The study observed that increasing pectin levels resulted in higher fat content which could be due to pectin affecting the jam's structure and potentially trapping fat globules. Similarly, Anwar et al. (2023) found an increase in fat content with the increase in date pit powder level to develop papaya jam. The results further showed that the fat content of the banana variety "Indial long (Hybrid variety)" was greater (1.15%) than the variety "Cavendish dwarf (local variety)" (1.08%). The interactive effect of pectin level at 15g × variety "Indial long (Hybrid variety)" resulted in maximum fat (1.39%) and the lowest fat (0.65%) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". Overall, the results suggest that both pectin levels and banana varieties significantly impact the fat content in banana jam. The observed results align with the findings of Awolu et al. (2018) who also observed fat content in the range of between 1.96 to 3.92% from blends of banana, pineapple, and watermelon pulp jam. Hassan et al. (2017) also observed a fat content of 5% in banana jam value added with collagen.

Crude fiber (%)

The crude fiber content of banana jam was maximum (0.50%) in 15g pectin levels, followed by pectin levels 10g with 0.33%, while the minimum crude fiber of 0.27% was recorded in 5g pectin levels (Table 3). The study showed that increasing pectin levels in the jam led to higher crude fiber content. This could be because pectin itself is a type of dietary fiber, and adding more pectin directly increases the fiber content of the jam. The results further showed that the crude fiber of the banana variety "Indial long (Hybrid variety)" was greater (0.37%) than the variety "Cavendish dwarf (local variety)" (0.36%). The interactive effect of pectin level at 15g × variety "Cavendish dwarf (local variety)" resulted in maximum crude fiber (0.53%), and lowest crude fiber (0.27%) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". Generally, banana jams are known to contain a low level of crude fibers (less than 2%) which is significantly lower than the crude fiber content of fresh bananas because the fiber in bananas is partially broken down during the cooking process. The results of the present study agreed with the findings of Awolu et al. (2018) who also observed crude fiber content in the range of 1.25 to 3.03% from blends of banana, pineapple, and watermelon pulp jam.

Titratable acidity (%)

The acidity preserves the jams from microorganisms' growth for a long period. The titratable acidity of the banana jam was maximum (0.32%) in 15g pectin levels, followed by 5g pectin levels with 0.26%, while the minimum titratable acidity of 0.25% was noted in 10g pectin levels (Table 3). The interaction of pectin and acid can be explained due to the breakdown of pectin into pectinic acid during the preparation of jam. Thus, the acidity value increases (Kanwal et al., 2017). The results further showed that the titratable acidity of the banana variety "Indial long (Hybrid variety)" were greater (0.33%) than the variety "Cavendish dwarf (local variety)" (0.23%). The interactive effect of pectin level at 15 g × variety "Indial long (Hybrid variety)" resulted in maximum titratable acidity (0.43%); and lowest titratable acidity (0.22%) was recorded in the interaction of 15g pectin levels × variety "Cavendish dwarf (local variety)". The titratable acidity of fruit jam is important because it affects the flavor, texture, and shelf life of the jam. The titratable acidity of fruit jam is determined by the number of natural acids in the fruits, as well as the amount of citric acid or other acids that are added during the jam-making process. The results of the present study align with the findings of Azira et al. (2021) who also observed TA in the range of between 0.083 to 0.063% in banana jam.

Table 3 Nutritional analysis of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Fat %			Crude Fiber %			Titratable acidity %		
	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	0.65	1.34	0.99b	0.27	0.28	0.27c	0.24	0.26	0.25a
T_2=(10g)	1.31	0.74	1.02b	0.30	0.36	0.33b	0.22	0.30	0.26a
T_3=(15g)	1.29	1.39	1.34a	0.53	0.47	0.50a	0.22	0.43	0.32a
Mean	1.08a	1.15a		0.36a	0.37a		0.23b	0.33a	
SE±	0.0920			0.0330			0.0489		
LSD 0.05	0.2049			0.0735			0.1089		

Varieties: CD = Cavendish Dwarf (Local variety); IL = Indial Long (Hybrid variety)

Potassium (mg 100 g^{-1})

The potassium value of banana jam was maximum (78.13 mg 100 g^{-1}) in 15g pectin levels, followed by pectin levels 10g with 77.97 mg 100 g^{-1}, while the minimum potassium value of 77.77 mg 100 g^{-1} was noted in 5g pectin levels (Table 4). These results suggest that higher levels of pectin may positively impact the potassium content in banana jam. The results further showed that the potassium value of the banana variety "Indial long (Hybrid variety)" were greater (78.01 mg 100 g^{-1}) than the variety "Cavendish dwarf (local variety)" (77.82 mg 100 g^{-1}). The interactive effect of pectin level at 15g × variety "Indial long (Hybrid variety)" resulted in a maximum potassium value (78.36 mg 100 g^{-1}), and the lowest potassium value (77.55 mg 100 g^{-1}) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". The potassium content was influenced by both pectin levels and the banana varieties. The interactive effects of these factors can result in variations in potassium levels, as

observed in the study. The results further agreed with the findings of Awolu et al. (2018) who also observed potassium in the range of between 8.37 to 80.77 mg 100 g^{-1} from blends of banana, pineapple, and watermelon pulp jam.

Iron (mg 100g^{-1})

The iron value of banana jam was maximum (0.82 mg 100g^{-1}) in 15g pectin levels, followed by pectin levels 10g with 0.80 mg 100g^{-1}, while the minimum iron value of 0.78 mg 100g^{-1} was noted in 5g pectin levels (Table 4). The results show that higher pectin levels are associated with slightly higher iron content in banana jam. The results further showed that the iron value of the banana variety "Indial long (Hybrid variety)" were greater (0.81 mg 100g^{-1}) than variety "Cavendish dwarf (local variety)" (0.79 mg 100g^{-1}). The interactive effect of pectin level at 15g × variety "Cavendish dwarf (local variety)" resulted in a maximum iron value (0.83 mg 100g^{-1}), and the lowest iron value (0.75 mg 100g^{-1}) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". The interaction between pectin level and banana variety also influenced iron content, with the highest and lowest values occurring at different combinations. This suggests that the effect of pectin level on iron content might be dependent on the banana variety used. The observed results further match with the findings of Awolu et al. (2018) who also recorded iron content in a range of between 0.46 to 0.84 mg 100 g^{-1} from blends of banana, pineapple, and watermelon pulp jam.

Calcium (mg 100g^{-1})

The calcium value of banana jam was maximum (1.56 mg 100g^{-1}) in 15g pectin levels, followed by pectin levels 10g with 1.53 mg 100g^{-1}, while the minimum calcium value of 1.49 mg 100g^{-1} was recorded in 5g pectin levels (Table 4). The study observed that increasing pectin levels in the jam slightly increased the calcium content. This could be due to the ability of pectin to bind and retain minerals from the fruit during the jam-making process. Similarly, Sulieman et al. (2013) also observed a similar increasing trend of results in orange pectin-based jam. The results further showed that the calcium value of the banana variety "Indial long (Hybrid variety)" was greater (1.62 mg 100g^{-1}) than the variety "Cavendish dwarf (local variety)" (1.43 mg 100g^{-1}). The interactive effect of pectin level at 15g × variety "Indial long (Hybrid variety)" resulted in a maximum calcium value (1.72 mg 100g^{-1}), and the lowest calcium value (1.31 mg 100g^{-1}) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". These recorded results imply that the choice of banana variety can significantly impact the nutritional composition of the jam, especially in terms of calcium content. The findings of the study are aligned with a previous study by Awolu et al. (2018) who also observed calcium content in a range of between 1.17 to 4.03 mg 100g^{-1} from blends of banana, pineapple, and watermelon pulp jam.

Table 4 Mineral analysis of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Potassium mg 100 g^{-1}			Iron mg 100 g^{-1}			Calcium mg 100 g^{-1}		
	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	77.55	78.00	77.77 c	0.75	0.81	0.78 c	1.31	1.67	1.49 c
T_2=(10g)	78.01	77.94	77.97 b	0.80	0.80	0.80 b	1.59	1.48	1.53 b
T_3=(15g)	77.90	78.36	78.13 a	0.83	0.82	0.82 a	1.40	1.72	1.56 a
Mean	77.82 b	78.01 a		0.79 b	0.81 a		1.43 b	1.62 a	
SE±	0.0114			0.0115			7.30303		
LSD 0.05	0.0254			0.0255			0.0163		

Varieties: CD = Cavendish Dwarf (Local variety); IL = Indial Long (Hybrid variety)

Magnesium (mg 100g^{-1})

The magnesium value of banana jam was maximum (1.36 mg 100g^{-1}) in 15g pectin levels, followed by pectin levels 10g with 1.12 mg 100g^{-1}, while the minimum magnesium value of 1.07 mg 100g^{-1} was noted in 5g pectin levels (Table 5). This suggests that higher pectin levels might favor the retention of magnesium during jam-making. The results further showed that the magnesium value of the banana variety "Indial long (Hybrid variety)" were greater (1.27 mg 100g^{-1}) than variety "Cavendish dwarf (local variety)" (1.10 mg 100g^{-1}). The interactive effect of pectin level at 15g × variety "Indial long (Hybrid variety)" resulted in a maximum magnesium value (1.44 mg 100g^{-1}), and the lowest magnesium value (0.81 mg 100g^{-1}) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". These results indicate that the magnesium content in banana jam is influenced by both the amount of pectin used and the type of banana variety. Higher pectin levels and the banana variety "Indial long" were associated with higher magnesium content. The interactive effects of these factors also played a role in determining the magnesium content in the jam. The study's findings align with Awolu et al. (2018) who also observed magnesium in a range of between 0.50 to 1.47 mg 100g^{-1} from blends of banana, pineapple, and watermelon pulp jam.

Sodium (mg 100g^{-1})

The sodium value of banana jam was maximum (29.62 mg 100g^{-1}) in 15g pectin levels, followed closely by pectin levels 10g with 29.58 mg 100g^{-1}, while the minimum sodium value of 29.56 mg 100g^{-1} was noted in 5g pectin levels (Table 5). Higher pectin levels in the jam contribute to the slightly higher sodium content. The results further

showed that the sodium value of the banana variety "Indial long (Hybrid variety)" was greater (29.67 mg $100g^{-1}$) than the variety "Cavendish dwarf (local variety)" (29.50 mg $100g^{-1}$). The interactive effect of pectin level at 15g × variety "Indial long (Hybrid variety)" resulted in a maximum sodium value (29.79 mg $100g^{-1}$), and the lowest sodium value (29.41 mg $100g^{-1}$) was recorded in the interaction of 5g pectin levels × variety "Cavendish dwarf (local variety)". These observed results suggest that different pectin levels and banana varieties influence the sodium content in the jam. These observed results align with the findings of Awolu et al. (2018) who also observed sodium in a range of between 9.30 to 30.70 mg $100g^{-1}$ from blends of banana, pineapple, and watermelon pulp jam.

Table 5 Mineral analysis of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Magnesium mg 100 g^{-1}			Sodium mg 100 g^{-1}		
	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	0.81	1.34	1.07c	29.41	29.71	29.56c
T_2=(10g)	1.22	1.03	1.12b	29.64	29.52	29.58b
T_3=(15g)	1.28	1.44	1.36a	29.46	29.79	29.62a
Mean	1.10b	1.27a		29.50b	29.67a	
SE±	0.1914			8.02803		
LSD 0.05	0.4265			0.0179		

Varieties: CD = Cavendish Dwarf (Local variety); IL = Indial Long (Hybrid variety)

Sensory attributes

The average scores for sensory attributes of banana jam are presented in Table 6. The score of color, flavor, texture, and overall acceptability was significantly ($P<0.05$) higher in 15g pectin levels i.e., 7.87, 7.78, 7.85, and 7.92, respectively, followed by 10g pectin levels i.e., 7.74, 7.75, 7.81, and 7.89 respectively, while a lower score of color, flavor, texture, and overall acceptability was observed in 5g pectin levels i.e., 7.73, 7.71, 7.78, and 7.84 respectively. Among varieties, the Indial Long (Hybrid variety) showed maximum sensory scores while banana jams from Cavendish Dwarf (Local variety) also obtained good sensory scores from the panel of judges. The results of the present study are in close agreement with the findings of Siddiqui et al. (2015) who also observed scores of appearances in a range of between 6.2 to 7.7, taste score between 6.4 to 7.9, aroma score between 6.2 to 7.9, texture score between 6.3 to 7.8 in banana jam. The results also relate to the findings of Awolu et al. (2018) who also observed scores of flavors in a range of between 3.40 to 5.00, the score of color between 2.10 to 5.00, and overall acceptability between 4.20 to 5.00 respectively in banana jam.

Table 6 Sensory attributes of banana jam as affected by different pectin levels and banana varieties

Pectin Levels	Color			Flavor			Texture			Overall acceptability		
	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean	CD	IL	Mean
T_1=(5g)	7.46	8.00	7.73c	5.55	7.87	7.71c	5.62	7.95	7.78c	5.72	7.97	7.84c
T_2=(10g)	7.53	7.96	7.74b	5.82	7.69	7.75b	5.70	7.78	7.81b	5.92	7.87	7.89b
T_3=(15g)	7.92	7.83	7.87a	6.50	7.94	7.78a	6.90	7.98	7.85a	6.23	8.04	7.92a
Mean	7.63b	7.93a		5.95b	7.83a		6.07b	7.90a		5.96 b	7.96a	
SE±	1.92503			3.84903			6.26603			8.25503		
LSD 0.05	4.28803			8.57603			0.0140			0.0184		

Varieties: CD = Cavendish Dwarf (Local variety); IL = Indial Long (Hybrid variety)

Conclusion

It can be concluded from the present study that pectin treatment of 15g/ kg^{-1} showed better performance on the overall quality of banana jam as well as sensorial characteristics followed by 10 g and 5 g pectin level treatments. Among varieties, the Indial long variety (Hybrid) was found to be the more suitable variety for banana jam as compared to the Cavendish dwarf (local variety) due to its high nutritional and sensory properties.

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