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INFLUENCE OF CITRIC ACID, ASCORBIC ACID, AND POTASSIUM METABISULFITE (KMS) PRE-TREATMENTS ON THE NUTRITIONAL COMPOSITION OF BANANA FLOUR

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ABSTRACT

This study explores the effect of different pretreatments on the nutritional quality of banana flour. The treatments applied included 0.5% citric acid, 1% citric acid, 0.5% ascorbic acid, 1% ascorbic acid, 0.5% potassium metabisulfite (KMS), 1% KMS, and a control (no treatment), with all treatments lasting for 10 minutes. The results revealed that moisture content was lowest in the 1% KMS-treated banana flour. Phenolic compounds, flavonoids, total soluble solids (TSS), and sugar content were highest in the 1% ascorbic acid-treated samples, indicating the potential for enhancing the bioactive properties and sweetness of the flour. Ash content was highest in both the 1% citric acid and 1% KMS-treated samples, suggesting that these pretreatments may help in retaining mineral content. The protein content was highest in the 1% KMS-treated flour, followed by the 1% citric acid treatment, indicating an enhancement of protein quality with these pretreatments. Fat content showed minimal variation across all treatments. The results suggest that pretreatments, particularly ascorbic acid and KMS greatly enhance the nutritional and functional qualities of banana flour, providing opportunities for its application in food items.

***Key words*:** Citric Acid, Ascorbic Acid, KMS, Nutritional Composition, Banana Flour**.**

Introduction

Bananas are one of the most widely consumed fruits globally, grown in a variety of climates and consumed by millions of people worldwide. Rich in essential nutrients such as potassium, vitamins (particularly vitamin C and vitamin B6), fiber, and antioxidants, bananas contribute to numerous health benefits, including supporting heart health, improving digestion, and boosting energy levels (Ranjha *et al*., 2022; Qamar *et al.* 2018). Beyond their immediate nutritional value, bananas also provide an affordable source of sustenance in many developing countries, making them a critical part of the global food supply.

Despite their many benefits, fresh bananas have a relatively short shelf life due to rapid ripening, physical damage, and susceptibility to microbial spoilage. These limitations pose challenges to both local markets and global supply chains, resulting in significant post-harvest losses (Murmu and Mishra, 2018). Consequently, there has been a growing interest in developing alternative methods to extend the usability of bananas, reduce waste, and enhance their shelf life while preserving or even improving their nutritional content. One promising solution is the production of banana flour, which has recently gained considerable attention in both the food industry and research. Banana flour is produced by drying and milling ripe or green bananas into a fine powder, making it a versatile and valuable ingredient for a range of food products.

The production of banana flour offers several advantages, including its longer shelf life compared to fresh bananas, ease of storage, and ability to retain many of the essential nutrients found in the fruit (Anyasi *et al*., 2013; Campuzano *et al*., 2018). Moreover, banana flour can be utilized in a variety of culinary applications, such as in gluten-free baking, baby food formulations, and as a functional food ingredient with potential health benefits (Afzal *et al*., 2022; Singh et al., 2016). Given its rising popularity, optimizing the processing methods for banana flour production has become a key area of research. Specifically, the pre-treatment of raw bananas before processing is crucial to ensuring the retention of nutrients, texture, and flavor during the drying and milling stages (Mohapatra *et al*., 2011; Gadhave *et al*., 2023; Ajayi, 2020).

One such method of pre-treatment involves the use of chemical agents such as citric acid, ascorbic acid, and potassium metabisulfite (KM). These substances are known to influence the physical and chemical properties of fruits, including reducing enzymatic browning, inhibiting microbial growth, and preserving the overall quality of the fruit. In addition to improving the appearance and safety of the final product, these chemical pretreatments may also impact the nutritive value of banana flour by preserving or altering the levels of key nutrients. However, the effectiveness of these treatments can vary depending on the concentration used, the duration of exposure, and the ripeness of the bananas at the time of processing. Therefore, understanding how these chemical pretreatments affect the nutrient profile of banana flour is essential to developing optimized processing methods that retain the health benefits of bananas while improving their culinary versatility and commercial value.

This research aims to investigate the effects of different concentrations of citric acid, ascorbic acid, and potassium metabisulfite on the nutritive value of banana flour. Specifically, it will assess the impact on key nutrients such as carbohydrates, proteins, vitamins, and minerals, as well as on the sensory and functional properties of the flour. Understanding the role of chemical pretreatments in preserving or enhancing the nutritive value of banana flour can contribute to the development of more sustainable and nutritious food products, addressing both food security concerns and the growing demand for healthier alternatives in the food industry.

Materials and methods

Materials

Mature bananas var. Grand Nain (*Musa spp*.) were procured from a local market. The bananas were carefully selected to ensure uniformity in maturity and were used immediately after procurement. Chemical reagents including citric acid, ascorbic acid, and potassium metabisulfite (KMS) were obtained from standard laboratory suppliers and were of analytical grade. All other chemicals and reagents used for analysis were also of analytical grade.

Preparation of Banana Flour

Bananas from each treatment group, including the control, were peeled and cut into uniform slices (approximately 0.5 cm thick). The slices were then subjected to the respective pretreatments. To prepare the pretreatments, each solution of citric acid, ascorbic acid, or potassium metabisulfite was prepared by dissolving the appropriate amount of the chemical in distilled water. The banana slices were immersed in the solution for the specified time (10 minutes) while stirring occasionally to ensure uniform exposure. After the treatment, the banana slices were drained and rinsed with clean water to remove any residual chemicals.

The treated banana slices were then subjected to drying in an oven at 60°C for 24 hours to reduce the moisture content to a stable level. Once dried, the slices were ground into a fine powder using a laboratory grinder. The banana flour produced from each treatment group was stored in airtight containers in a cool, dry place until further analysis.

Pretreatments

The experiment was designed to evaluate the effects of various chemical pretreatments on the nutritive value of banana flour. To achieve this, six different chemical treatments were applied to the bananas, each at two different concentrations and with a fixed exposure time of 10 minutes. The treatments included 0.5% citric acid, 1% citric acid, 0.5% ascorbic acid, 1% ascorbic acid, 0.5% potassium metabisulfite (KMS), and 1% KMS, and each treatment was replicated three times using a Completely Randomized Block Design. These treatments were chosen to assess the impact of different chemicals and concentrations on the quality of the resulting banana flour. In addition to these pretreatments, a control group consisting of untreated bananas was included in the study to serve as a baseline for comparison. This experimental setup allowed for a comprehensive analysis of how varying chemical pretreatments influence the nutritive content of banana flour, including important parameters such as moisture, ash, fat, carbohydrates, protein, phenols, and flavonoids.

Nutrient analysis

Moisture content was determined using the oven-drying method, where a 5 g sample was weighed, dried at 105°C, and the moisture loss calculated. Ash content was assessed by incinerating a 2 g sample in a muffle furnace at 550°C for 6 hours. Fat content was determined using the Soxhlet extraction method, where a 3 g sample was extracted with petroleum ether. Total soluble solids (TSS) were measured using a refractometer on a banana flour suspension in distilled water. Protein content was determined by the Kjeldahl method, involving digestion, distillation, and titration, with a nitrogen-to-protein conversion factor of 6.25. Phenolic content was analyzed using the Folin-Ciocalteu method, while flavonoid content was measured by the aluminum chloride colorimetric method. Both phenolic and flavonoid contents were expressed as gallic acid equivalent (GAE) and quercetin equivalent (QE) per gram of sample, respectively.

Result and Discussion

The results of the study show that different pretreatments significantly affected the nutrient content of banana flour. The control sample had the highest moisture content (12.85%), which decreased in most pretreatments, with the 1% KMS treatment exhibiting the lowest moisture content (8.35%). This might be due to that potassium metabisulfite (KMS) may be particularly effective in reducing moisture, possibly due to its preservative properties (Desalegn Melese *et al*., 2022). Citric acid treatments (both 0.5% and 1%) resulted in moderate moisture reduction, indicating that citric acid can also help reduce water retention, though not as effectively as KMS. Regarding ash content, the 1% citric acid treatment resulted in the highest value (3.70%), followed by 1% KMS (3.27%), indicating that citric acid might enhance the extraction or retention of minerals in the banana flour (Anyasi *et al*., 2018). The ascorbic acid treatments, on the other hand, resulted in lower ash content, with the 1% ascorbic acid treatment showing the lowest ash value (2.43%). This could be due to ascorbic acid's reducing properties, which might interfere with mineral retention. In terms of fat content, the differences among treatments were minimal, with the 1% ascorbic acid sample showing the highest fat content (0.89%). This slight increase in fat could be attributed to the enhanced stability provided by ascorbic acid, which may help retain some of the fat in the banana flour. Finally, for total soluble solids (TSS), ascorbic acid (especially 1%) resulted in the highest TSS (3.57%), followed by citric acid (3.44%), portentous that these acids might increase the solubility of sugars or other soluble compounds in banana flour (Anyasi *et al*., 2015). The 0.5% KMS treatment, however, led to the lowest TSS (2.44%), indicating that KMS might limit the solubility of certain components.

For sugar content, the differences between pretreatments were not as pronounced. The highest sugar content was observed in the 1% Ascorbic acid-treated flour (2.91%), followed by 0.5% Ascorbic acid (2.54%). This suggests that ascorbic acid may have a small influence on sugar formation or stabilization. Ascorbic acid's antioxidative properties might prevent the conversion of starch to sugars, preserving the sugar content in the flour.

In contrast, 0.5% KMS treatment resulted in the lowest sugar content (2.12%), indicating that KMS might prevent the conversion of carbohydrates to sugars to a greater extent than other pretreatments (Bharathi Devi *et al*., 2020; Bharani *et al*., 2016). The control sample, with a sugar content of 2.1467%, was similar to most of the pretreatment samples, suggesting that while pretreatments influence carbohydrate retention, they do not drastically affect sugar formation.

Protein content also varied significantly across the treatments. The highest protein content was observed in the 1% KMS treatment (3.18%), followed by 1% Citric acid (3.03%) and 1% Ascorbic acid (2.87%). KMS's effect on protein content may be attributed to its ability to prevent protein degradation, possibly by inhibiting protease activity or stabilizing protein structures during processing (Bakare *et al*., 2017; Kamal *et al*., 2022). Citric acid, being an acidulant, could influence protein solubility or interact with proteins, leading to slightly higher protein retention compared to other pretreatments (Anyasi *et al*., 2015). Ascorbic acid, despite its antioxidant effects, resulted in a moderate increase in protein content. The control sample had a protein content of 2.44%, which was lower than most treated samples, further indicating that pretreatments may enhance protein retention in banana flour. The increase in protein content with pretreatments suggests that they may help in preventing protein loss during the flour production process.

The pretreatment with 1% Ascorbic acid resulted in the highest phenolic content (97.6 mg/g), which indicates that ascorbic acid may enhance the accumulation or preservation of phenolic compounds in banana flour. Ascorbic acid is a known antioxidant, and its ability to prevent oxidation could help maintain the stability of phenolic compounds during processing. The positive effect of ascorbic acid in increasing phenolic content is likely due to its role in protecting phenolics from oxidative degradation (Anyasi *et al*., 2018, Gadhave *et al*., 2023). The 1% Citric acid pretreatment also showed a significant increase in phenolic content (92.44 mg/g), suggesting that citric acid, possibly by adjusting the pH or by interacting with phenolic compounds, may help preserve or enhance their levels during flour production. KMS (potassium metabisulfite), while effective in increasing carbohydrate retention in other contexts, had a lower effect on phenolic content (90.22 mg/g) compared to ascorbic acid and citric acid. This suggests that KMS may not have the same antioxidant or stabilizing effect on phenolics as ascorbic acid and citric acid. The control sample had the lowest phenolic content (78.19 mg/g), which underscores the positive impact of pretreatments in enhancing the phenolic levels in banana flour. It is evident that pretreatments, especially those with antioxidant properties like ascorbic acid, have the potential to improve the phenolic content of the flour.

Similar trends were observed for flavonoid content. 1% Ascorbic acid treatment resulted in the highest flavonoid content (86.76 mg/g), suggesting that ascorbic acid not only preserves phenolics but also enhances flavonoid accumulation. Flavonoids are also known for their antioxidant properties, and their stabilization during processing might be supported by the antioxidant effects of ascorbic acid (Anyasi et al., 2017, Udomkun et al., 2021). 1% Citric acid also showed a significant increase in flavonoid content (83.00 mg/g), which is consistent with its effect on phenolic compounds. As with phenols, citric acid may be enhancing flavonoid stability through pH changes or other mechanisms during flour production. KMS treatment resulted in a moderate increase in flavonoid content (82.10 mg/g), similar to its effect on phenolic content, suggesting that KMS may provide some protection to flavonoids, but not as effectively as ascorbic acid or citric acid. The control sample had the lowest flavonoid content (74.46 mg/g), supporting the idea that pretreatments, especially those with antioxidant properties like ascorbic acid, significantly contribute to higher flavonoid levels in banana flour.

Conclusion

Pretreatments with citric acid, ascorbic acid, and potassium metabisulfite (KMS) significantly affected the nutritional quality of banana flour. The 1% KMS treatment resulted in the lowest moisture and highest protein content, while 1% ascorbic acid led to the highest levels of phenols, flavonoids, total soluble solids (TSS), and sugars. Ash content was highest for 1% citric acid and 1% KMS. These results indicate that pretreatments, particularly with ascorbic acid and KMS, can improve the nutritional and functional properties of banana flour, making it a promising option for developing enhanced food products.

Table 1 : Effect of pretreatments on nutritional content of banana flour

Pretreatments	Moisture	Ash	Fat	TSS
0.5% Citric acid for 10 min	9.11	3.01	0.77	3.03
1% Citric acid for 10 min	9.23	3.70	0.68	3.44
0.5% Ascorbic acid for 10 min	10.2	2.45	0.60	3.11
1% Ascorbic acid for 10 min	10.5	2.43	0.89	3.57
0.5% KMS for 10 min	10.12	2.30	0.69	2.44
1% KMS for 10 min	8.15	3.27	0.62	2.78
Control	12.85	1.95	0.68	2.61
S. Em±	0.146	0.04	0.09	0.047
CD @ 1%	0.456	0.14	0.03	0.146

Table 2 : Effect of pretreatments on sugar and protein content of banana flour

Pretreatments	Sugars	Protein
0.5% Citric acid for 10 min	2.29	2.68
1% Citric acid for 10 min	2.2	3.03
0.5% Ascorbic acid for 10 min	2.54	2.64
1% Ascorbic acid for 10 min	2.91	2.87
0.5% KMS for 10 min	2.12	2.76
1% KMS for 10 min	2.16	3.18
Control	2.15	2.443333
S. Em±	0.036	0.044
CD @ 1%	0.113	0.134

Table 3 : Effect of pretreatments on secondary metabolites of banana flour

Pretreatments	Phenols	Flavonoids
0.5% Citric acid for 10 min	84.12	79.78
1% Citric acid for 10 min	92.44	83.00
0.5% Ascorbic acid for 10 min	87.65	81.45
1% Ascorbic acid for 10 min	97.60	86.76
0.5% KMS for 10 min	78.11	76.24
1% KMS for 10 min	90.22	82.11
Control	78.19	74.46
S. Em±	1.35	1.74
CD @ 1%	4.21	5.44

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