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IMPACT OF DIFFERENT PRETREATMENTS ON NUTRITIONAL, FUNCTIONAL, AND COLOR PROPERTIES OF BANANA FLOUR

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ABSTRACT

In this study, we looked at how different pretreatments like citric acid, ascorbic acid, and potassium metabisulfite (KMS) at 0.5% and 1% concentrations affected the quality of banana flour. Using a Completely Randomized Design, we compared these treatments with a control group that had no pretreatment. Results showed that the treatments lowered the moisture content of the flour. The 1% KMS treatment had the least moisture at 8.15%, compared to the control at 12.85%. The 1% citric acid treatment raised the ash content to 3.70%, whereas the lowest water activity was found in the 1% KMS treated flour at 0.47 aw. The 1% ascorbic acid treatment gave the highest crude fiber content at 6.78%. Color tests indicated that the flour treated with 1% KMS had the brightest color with the highest lightness (L* value of 79.34). Additionally, the solubility was greatest in the 1% citric acid treatment while the highest swelling power (3.06) and water absorption (7.84 g/g) were measured in the 1% KMS.
***Keywords* :** Banana flour, Pretreatments, Functional properties, Colour profile

Introduction

Banana flour, made from green bananas, is becoming a popular gluten-free option for those with dietary restrictions like celiac disease. It's a nutritious choice because it’s rich in fiber and essential nutrients, making it a good alternative to regular flours. As more people look for gluten-free and plant-based options, banana flour is getting attention as a healthy alternative to traditional grain flours (Menezes *et al.*, 2011; Pragati *et al.*, 2014). The unripe bananas used to make this flour are treated to retain their healthful qualities while retaining a mild flavor and adaptable texture that may be used in a variety of culinary creations. In addition to being gluten-free, banana flour is a desirable choice for enhancing total nutritional intake because it is high in dietary fiber, resistant starch, and vital vitamins and minerals. With growing consumer demand for gluten-free and plant-based ingredients, banana flour is also being explored as a sustainable and healthy alternative to traditional grain-based flours (Compuzano *et al.*, 2018; Kaur *et al.*, 2017).

Beyond its nutritional value, banana flour's functional properties, including starch content, rehydration ability, and water absorption capacity, are crucial for its successful use in food products, impacting texture, consistency, and cooking behavior. However, these properties can vary considerably depending on the processing methods employed, particularly the pretreatment techniques used during flour production. The application of different pretreatments is vital in determining the final functional characteristics of the flour, including its starch gelatinization behavior, rehydration properties, and overall nutrient retention (Falade. and Oyeyinka, 2015).

Citric acid, ascorbic acid and potassium metabisulfite (KMS) pretreatment processes can change the way flour behaves in diverse ways. Important characteristics of the flour, such as its starch structure and ability to retain specific chemicals, as well as its general quality, including flavor, color, texture, and shelf life, may be impacted by these treatments. Citric acid, for instance, is a naturally occurring acid that aids in lowering the pH of banana tissue. This increases our ability to digest starch and facilitates its breakdown. Its antioxidant properties also keep the flour from browning, improving its appearance throughout processing and storage (Kuyu *et al*., 2018).

Ascorbic acid plays pivotal role in preserving the nutritional quality of banana flour. It is particularly effective at preventing oxidative damage to sensitive nutrients, such as vitamins and phenolic compounds, which could otherwise degrade during processing. Additionally, ascorbic acid may help to preserve the integrity of the starch molecules, potentially reducing their retrogradation during storage and enhancing the flour's rehydration properties (Ahmed *et al*., 2010).

Potassium metabisulfite (KMS), a chemical preservative, is commonly used to inhibit the activity of enzymes that can cause spoilage, such as polyphenol oxidase, which leads to browning in fruits and vegetables. It also has antimicrobial properties, preventing the growth of harmful microorganisms that could affect the quality of the flour. However, the use of KMS may alter the flavor profile slightly and requires careful handling to ensure it is used within safe limits (Atif *et al*., 2018).

The control treatment, which involves no pretreatment, serves as a baseline for comparison against the modified treatments. By comparing the control to the pretreatments, this study can highlight the specific benefits and potential trade-offs associated with each pretreatment, enabling a more informed decision on which method best enhances the quality and functionality of banana flour for use in food products.

These pretreatment techniques offer promising methods for optimizing banana flour's characteristics and expanding its applications. They can help address challenges such as starch digestibility, texture, color retention, and shelf-life stability, which are critical factors in the widespread adoption of banana flour in the food industry. This study aims to assess the influence of these various pretreatment methods on the nutritional parameters, starch content, and rehydration properties of banana flour. Understanding how these pretreatments affect the flour's starch content, rehydration ability, and nutrient retention is crucial for enhancing the quality and application of banana flour in food formulations, with the ultimate goal of promoting its use as a healthy and sustainable ingredient in modern diets.

Materials and Methods

Banana flour preparation

Mature Grand Nain bananas (*Musa spp*.) were obtained from a local market. They were peeled, sliced into ~0.5 cm pieces, and immediately subjected to pretreatments. Pretreatment solutions (citric acid, ascorbic acid, or potassium metabisulfite) were prepared in distilled water, and slices were immersed for 10 minutes with occasional stirring. Afterward, slices were rinsed, drained, and dried in an oven at 60°C for 24 hours. The dried slices were ground into fine flour and stored in airtight containers for further analysis.

Proximate analysis

Moisture content was measured 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. Water activity was measured using a water activity meter. Crude fibre is measured by treating defatted flour with acid and alkali to remove digestible parts. The remaining residue is dried, weighed, and burned in a furnace. The crude fibre content is calculated from the weight difference before and after ashing and is expressed as a percentage of the sample (AOAC, 2002).

Colour profile

The colour profile of banana flour was measured using a HunterLab colorimeter, which records values based on the L**a**b*. The L* value represents lightness, ranging from 0 (black) to 100 (white). The a* indicates the red-green axis, with positive values showing redness and negative values representing greenness. The b* reflects the yellow-blue axis, where positive values denote yellowness and negative values specify blueness. The whiteness index (WI) of the banana flour samples was calculated from the L*a*b* values following the method described by Gadhave *et al*. (2023), using Equation (1).

$$WI = 100 - \sqrt{(100 - L)^2 + a^2 + b^2}$$

Functional properties

The solubility index and swelling power of banana flour were determined using the method described by Kusumayanti *et al*. (2015) with slight modifications. Approximately 1 g of banana flour was weighed into a centrifuge tube and mixed with 10 mL of distilled water. The mixture was heated in a water bath at 85°C for 30 minutes with occasional stirring. After heating, the sample was cooled to room temperature and centrifuged at 3000 rpm for 15 minutes. The supernatant was carefully decanted into a pre-weighed dish and dried at 105°C until constant weight to determine the solubility index, expressed as the percentage of soluble solids. The weight of the gel-like sediment remaining in the centrifuge tube was used to calculate the swelling power, expressed as the ratio of the weight of the wet sediment to the original sample weight. Water absorption capacity was measured following the method of Kakar *et al*. (2022). One gram of banana flour was mixed with 10 mL of distilled water in a centrifuge tube. The mixture was allowed to stand at room temperature for 30 minutes, with occasional shaking, and then centrifuged at 3000 rpm for 15 minutes. The supernatant was discarded, and the weight of the absorbed water was recorded. WAC was expressed as the grams of water absorbed per gram of flour (g/g).

Statistical analysis

The experimental data were analyzed using Completely Randomized Design (CRD) with seven treatments and three replications. Statistical analysis was carried out using GRAPES software to determine the significance of treatment effects on various parameters. The results were expressed as mean values, and the significance of differences among treatments was tested using Analysis of Variance (ANOVA). The Standard Error of Mean (SEm) and Critical Difference (CD) at 1% level of significance ($p < 0.01$) were calculated to compare treatment means.

Results and Discussion

The application of various pretreatments had a notable impact on the nutritional composition of banana flour (Table 1). Moisture content was significantly reduced in all pretreated samples compared to the control, which recorded the highest value (12.85%). Among the treatments, 1% potassium metabisulfite (KMS) resulted in the lowest moisture level (8.15%), indicating its effectiveness in enhancing the drying process. Lower moisture content is desirable in flour production, as it improves shelf life and minimizes microbial growth (Nasir *et al*. 2004; Desalegn and Kibr, 2021). Citric and ascorbic acid treatments also reduced moisture content, although to a lesser extent than KMS. Ash content, representing the total mineral content, was highest in the 1% citric acid treatment (3.70%), followed closely by 1% KMS (3.27%). The control had the lowest ash content (1.95%), suggesting that pretreatments may help in preserving or enhancing mineral retention during processing. The increased ash content in treated samples could also be attributed to a concentration effect due to moisture reduction or minimized mineral loss during drying (Kuyu *et al*., 2018; Fana Haile and Fisseha, 2015). Water activity is a critical factor in determining microbial stability and shelf life. All pretreatments significantly reduced water activity compared to the control (0.79 aw), with the 1% KMS treatment achieving the lowest value (0.47 aw). This suggests that KMS is particularly effective in reducing the availability of free water in the product. Both citric and ascorbic acid treatments also showed a reduction in water activity, contributing to improved storage potential. Crude fibre content was highest in the flour treated with 1% ascorbic acid (6.78%), followed by 1% citric acid (6.68%). These treatments may help preserve or stabilize fibre components during thermal processing. In contrast, the control and KMS-treated samples showed comparatively lower fibre content. The antioxidant properties of ascorbic acid might have played a role in protecting fibrous materials from degradation during drying (Desalegn Melese and Olika Keyata, 2022).

The color attributes of banana flour represented by L*, a*, b*, and Whiteness Index (WI)were significantly influenced by different pretreatments, as presented in Table 2. The L* values, which indicate lightness (0 = black, 100 = white), ranged from 62.56 in the control to 79.34 in the 1% KMS treated sample. All pretreated samples exhibited significantly higher L* values compared to the control, indicating improved brightness and visual whiteness. Among treatments, 1% KMS pretreatment yielded the highest L* value (79.34), followed by 1% citric acid (75.34) and 1% ascorbic acid (73.12). The increase in lightness can be attributed to the inhibitory effect of pretreatments on enzymatic browning reactions, particularly polyphenol oxidase (PPO) activity, which typically darkens banana products during drying (Desalegn Melese, and Olika Keyata, 2022; Bekele and Emire, 2023).

The a* values ranged from 1.54 (1% KMS) to 3.56 (control). The control sample had the highest redness intensity, indicating more browning. All pretreatments led to a significant reduction in a* values, suggesting effective suppression of enzymatic browning. The lowest a* value observed in the 1% KMS treatment signifies minimal red pigmentation, which contributes to a cleaner, whiter flour appearance. This substantial reduction suggests that the pretreatments, particularly with KMS, effectively suppressed enzymatic browning likely through inhibition of polyphenol oxidase (PPO) activity, which is responsible for oxidative discoloration in banana tissues during processing (Sarpong *et al*., 2018).

The b* values, indicating yellowness, were also reduced by pretreatments, ranging from 14.12 (1% citric acid) to 21.56 (control). Lower b* values are desirable for high whiteness, as they reflect reduced yellowness. Again, all pretreated samples showed significantly lower b* values than the control. Notably, both 1% KMS and 1% citric acid treatments were most effective in reducing b*, correlating well with their higher whiteness indices.

The Whiteness Index followed a similar trend to the L* values, ranging from 62.56 (control) to 79.34 (1% KMS). Pretreatments, especially at higher concentrations, significantly enhanced the WI of banana flour. The 1% KMS treatment was most effective, followed closely by 1% citric acid and 1% ascorbic acid. The increase in WI is a direct result of combined improvements in L*, and reductions in a* and b*, reflecting the reduced browning and better color preservation due to pretreatment.

The solubility index, water absorption capacity (WAC) and swelling power (both expressed in g/g) of banana flour were significantly influenced by different pretreatments (Table 3). The solubility index (g/g) of banana flour ranged from 5.92 (control) to 7.80 (1% citric acid). All pretreated samples demonstrated significantly higher solubility compared to the control, indicating improved dispersion of starch molecules in water. The highest solubility was observed in 1% citric acid-treated flour, followed by 0.5% citric acid (7.67) and 1% ascorbic acid (7.34). The increase in solubility can be attributed to the partial breakdown of starch granules or weakening of intermolecular hydrogen bonds due to the action of acidic pretreatments, which likely facilitated better water interaction and solubilization of starch components (Anyasi *et al*., 2017; Trithavisup and Charoenrein, 2016).

Water absorption and swelling power are closely related, as higher water absorption usually results in greater swelling of starch granules. The control sample displayed the lowest values for both swelling power (1.73) and WAC (5.66), indicating limited ability of the untreated starch granules to hydrate and expand. This might be the result of a more compact granule structure or the presence of processing-related enzyme degradation that reduces water interaction (Wang and Copeland, 2013). Among the treatments, all pretreated samples showed a significant increase in both parameters compared to the control. The highest swelling power (3.06) and WAC (7.84) were observed in flour pretreated with 1% KMS, indicating that sulfite treatment helped preserve the integrity and water-binding sites of starch molecules (Liu *et al*., 2014). This enhanced hydration capacity can be attributed to the prevention of browning and cross-linking reactions that may otherwise hinder water uptake. Similarly, 1% citric acid and 1% ascorbic acid also resulted in significantly higher swelling and WAC values compared to the control. These acids likely modified the starch structure by slightly breaking down intermolecular hydrogen bonds, thus increasing water penetration and granule expansion (Zhang *et al*., 2023). The trend observed across all treatments clearly shows that higher WAC is directly associated with increased swelling power, confirming their functional interdependence.

Conclusion

Different pretreatments had a notable impact on the quality of banana flour. Among them, 1% KMS was most effective, resulting in lower moisture and water activity with better color properties with increased lightness and reduced a* and b* values. It also showed the highest swelling power and water absorption, indicating improved functional properties. Ascorbic acid enhanced fibre content and also improved quality, followed by citric acid**.** Overall, 1% KMS produced the best quality banana flour among the treatments tested.

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

Pretreatments	Moisture	Ash	Water activity	Crude fibre
0.5% Citric acid for 10 min	9.11	3.01	0.63	6.30
1% Citric acid for 10 min	9.23	3.71	0.52	6.68
0.5% Ascorbic acid for 10 min	10.21	2.45	0.57	6.21
1% Ascorbic acid for 10 min	10.51	2.43	0.58	6.78
0.5% KMS for 10 min	10.12	2.3	0.6	5.60
1% KMS for 10 min	8.15	3.27	0.47	5.83
Control	12.85	1.95	0.79	5.81
S. Em±	0.15	0.04	0.02	0.10
CD @ 1%	0.46	0.13	0.05	0.30

Table 2 : Effect of pretreatments on colour characters of banana flour

Pretreatments	L*	a*	b*	Whiteness index
0.5% Citric acid for 10 min	69.12	2.62	18.62	69.12
1% Citric acid for 10 min	75.34	1.82	14.12	75.34
0.5% Ascorbic acid for 10 min	70.11	2.68	16.68	70.11
1% Ascorbic acid for 10 min	73.12	1.96	15.46	73.12
0.5% KMS for 10 min	70.23	2.23	17.23	70.23
1% KMS for 10 min	79.34	1.54	14.34	79.34
Control	62.56	3.56	21.56	62.56
S. Em±	1.093	0.037	0.26	1.09
CD @ 1%	3.348	0.114	0.795	3.35

Table 3 : Effect of pretreatments on functional properties of banana flour

Pretreatments	Solubility index	Water absorbing capacity	Swelling power
0.5% Citric acid for 10 min	7.67	6.32	2.52
1% Citric acid for 10 min	7.80	7.54	2.88
0.5% Ascorbic acid for 10 min	7.12	6.56	2.66
1% Ascorbic acid for 10 min	7.34	7.34	2.82
0.5% KMS for 10 min	6.45	6.87	2.65
1% KMS for 10 min	6.68	7.84	3.06
Control	5.92	5.66	1.73
S. Em±	0.11	0.106	0.043
CD @ 1%	0.34	0.326	0.133

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