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ORIGINAL ARTICLE

Food Chemistry, Engineering, Processing and Packaging

Effect of peanut-skin fortification on oil separation and consumer acceptance of sesame butter

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ABSTRACT

Background: Sesame butter offers a rich source of health benefits, but its commercial viability is hampered by oil separation during storage. **Aims:** This study aimed to develop a sesame butter formulation with improved oil retention capacity using peanut skins (PS) as a natural thickening agent, while also evaluating consumer acceptance of the resulting product. **Material and Methods:** Sesame butter was prepared from roasted sesame seeds. The formulation was then reformulated with the incorporation of PS at varying concentrations (0.0%, 0.5%, 1.0%, 2.0%, 5.0% and 10.0%). Oil separation in these formulations was monitored throughout a storage period of 63 days, with measurements recorded at regular intervals (1, 3, 5, 7, 14, 21, 28, 35, 42, 49, 56 and 63 days). To assess consumer acceptability, 50 untrained panelists evaluated the sensory attributes (flavor, texture, and overall acceptance) of the sesame butter formulations using a 9-point hedonic scale. **Results:** Consumer acceptance of the sesame butter was primarily influenced by the formulation's sensory characteristics, particularly flavor and color. Texture did not significantly impact overall acceptance ($p = 0.975$). Notably, the degree of oil separation significantly decreased ($p = 0.00$) with increasing PS concentration. A marked reduction in oil separation occurred after 14 days of storage. Formulations containing 10.0% and 5.0% PS exhibited the most effective oil retention, while the 1.0% PS formulation received the highest consumer ratings for flavor, texture, and overall acceptability. **Conclusion:** This study demonstrates the potential of peanut skins as a viable food additive to enhance oil retention capacity and consumer acceptance of sesame butter. Notably, the optimal PS concentration for improved functionality and consumer preference appears to be at a lower level (1.0%). This finding suggests the potential for effective oil separation control without compromising consumer perception of the product.

Keywords: Sesame seeds, Peanut skin concentration, Oil separation, Oil retention.

ARTICLE INFORMATION

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1 Introduction

Sesame seed butter refers to a paste made from cleaned, dehulled, roasted and grinded sesame seeds (Razavi et al., 2008). This spreadable product finds application not only as a standalone food but also as an ingredient in bakery and confectionery items (Guneser and Zorba, 2011). Due to the high nutritional content of sesame seeds, the resulting paste is considered a valuable source of nutrients and health benefits for human consumption. However, sesame seed butter presents a unique challenge: it is a colloidal suspension comprised of sesame oil and hydrophilic particles (Çiftçi et al., 2008). The high oil content, consisting primarily of susceptible unsaturated fatty acids, has a tendency to migrate to the surface of the butter. This phenomenon, observed in unstabilized sesame seed butter, leads to a reduced shelf life and a textural shift towards hardness. (Elleuch et al., 2014). Additionally, oil leakage during transportation can contaminate packaging, rendering the product unappealing and ultimately rejected by consumers (Guneser and Zorba, 2011).

Oil separation constitutes a significant quality issue in sesame paste negatively impacting its visual appeal during extended storage periods. Consumer acceptability of sesame seed butter by consumers is mainly influenced by appearance and spreadability on various bakery items like bread, buns, and rolls (Munekata et al., 2016). During storage, a distinct phase separation occurs, with the bulk of the oil migrating upwards and the solid hydrophilic particles settling at the bottom. This results in the formation of two distinct phases and a consequent textural change, rendering the sesame butter tough and lacking smoothness (Elleuch et al., 2014). Furthermore, oil leakage during transportation not only contaminates the packaging but also leads to consumer rejection of the product (Guneser and Zorba, 2011). This not only negatively affects consumer acceptance but also damages the manufacturer's reputation when attempting to market the sesame seed butter. Therefore, the development of shelf stable sesame seed butter with optimal sensory and nutritional properties becomes a crucial objective.

Peanut skins, the layer immediately surrounding and protecting peanut seeds (Davis et al., 2010), are a by-product of peanut butter production that holds promise in mitigating or preventing oil separation in sesame seed butter (Mohebpour et al., 2023). Their high fiber content translates to a potential for retaining both water and fat within food products (Laurrari et al., 2012; Elleuch et al., 2014). By incorporating peanut skins, researchers anticipate improvements in emulsion stability and a significant increase in the hardness of sesame paste. Additionally, these skins, acting as an alternative source of antioxidants, could potentially be used to prevent oil separation, lipid oxidation, sensory attribute degradation, and the decline of nutritional properties – all critical concerns in high oil content foods (Çiftçi et al., 2008). Notably, peanut skins have the potential to stabilize the polyunsaturated fatty acids during sesame paste storage.

With consumers exhibiting a growing interest in fresh, natural, minimally processed, and additive-free food options for health reasons (Mesías et al., 2008), peanut skin-fortified sesame butter has the potential to achieve high levels of consumer acceptance. To the best of our knowledge, no existing research has investigated the use of peanut skins to prevent oil separation in sesame butter and enhance its overall quality during storage. The study aims to establish the precise effect of incorporating peanut skins on the extent of oil separation from sesame butter and ultimately, the consumer acceptability of the resulting product.

2 Material and Methods

2.1 Formulation of peanut-skin fortified sesame butter

This study employed a randomized experimental design to investigate the effect of peanut skin incorporation on sesame seed butter characteristics. Dry white sesame seeds (5 kg) were procured from Mbare Produce Market in Harare, Zimbabwe. To ensure uniformity, the seeds were meticulously sorted and handpicked to remove any debris or extraneous materials. Subsequently, they were winnowed for further cleaning. The cleaned underwent dehulling, followed by roasting in a domestic oven at a controlled temperature of 160 ℃ for 10 minutes. Finally, the roasted seeds were ground into a fine paste using a high-speed industrial blender (Mohamed Ahmed et al., 2021). Peanuts were similarly roasted in an oven at 160 ℃ for 10 minutes before being allowed to cool to room temperature. The peanut skins were then meticulously separated from the peanut kernels. These skins were subsequently ground into a fine meal using a food blender. The prepared peanut skin meal was then incorporated into the sesame seed butter at predetermined concentrations: 0.0%, 0.5%, 1.0%, 2.0%, 5.0% and 10.0%. To ensure data reproducibility, all samples were prepared in triplicate.

2.2 Physical characteristic determination

Sesame seed butter samples were dispensed into identical plastic bottles and arranged in ascending order of their peanut skin (PS) concentration on a white ceramic tile base. The illumination within the room was a maintained as either artificial or natural light. The color of each sample was then qualitatively assessed through visual inspection by trained personnel.

2.3 Oil separation determination

The effectiveness of PS in inhibiting oil separation was evaluated using a modified version of the method reported by Ereifej et al., (2005). Briefly, 25 g of sesame seed butter containing varying PS concentrations (0%, 0.5%, 1.0%, 2.0%, 5.0% and 10.0%) were weighed into individual 50 mL plastic cups. To facilitate the passage of separated oil, the cups were covered with perforated aluminum foil. Subsequently, the inverted cups were placed within plastic Petri dishes containing five filter papers each. These filter papers served to absorb the separated oil from the butter samples. The weight of each Petri dish, including the filter papers with adsorbed oil, was measured at predetermined storage intervals: 0, 1, 3, 5, 7, 14, 21, 28, 35, 42, 49, 56, and 63 days. The percentage of oil separation for each measurement day was then calculated using Equation (1):

$$\textit{Oil separation}\ \% = \frac{(B-A)}{M} \times 100 \ldots\ldots\ldots\ (1)$$

Where:

A: original weight (g) of filter papers and the petri dish before the test.
B: weight (g) of filter papers and the petri dish with separated oil.
M: weight (g) of seed butter sample at the beginning of test (Zebib et al., 2015).

2.4 Sensory evaluation

A consumer acceptance test was conducted to assess the sensory attributes of the sesame seed butter samples. Fifty untrained panelists (36 males and 14 females), aged between 20 and 50 years, participated in the evaluation (Sanders et al., 2014). All panelists were confirmed to be free from food allergies, fluent English speakers, and none-smokers. For the evaluation, 10 grams of each sesame butter sample were presented in coded plastic cups. Each cup was assigned a unique three-digit random code to ensure anonymity during assessment. Prior to commencing the test, panelists received a briefing on the evaluation procedure. They were then instructed to rate the appearance, texture, flavor, and overall acceptability of the samples on provided score sheets. A nine-point hedonic scale was employed for the ratings, where 1 corresponded to "dislike extremely," 5 represented "neither like nor dislike," and 9 indicated "like extremely" (Sanders et al., 2014).

2.5 Statistical analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 23 using ANOVA (Analysis of Variance). All measurements and sensory attribute ratings were determined in triplicate. Data are reported as means ± standard deviation; (SD). Post-hoc Tukey's Least Significant Difference (LSD) test was conducted to identify significant differences ($p < 0.05$) in oil separation measurements and sensory attribute ratings between the sesame seed butter samples with varying peanut skin concentrations.

3 Results

3.1 Physical properties

The control sesame butter sample exhibited a light ivory white color, characteristic of white sesame seeds. Samples containing 0.5% and 1.0% PS displayed a light brown coloration, while the sample with 2.0% PS presented a brown color. A progressive darkening effect was observed with increasing PS concentration, as samples stabilized with 5.0% and 10.0% PS exhibited a dark brown color. Visual representations of the developed PS-fortified sesame butters are presented in Figure 1.

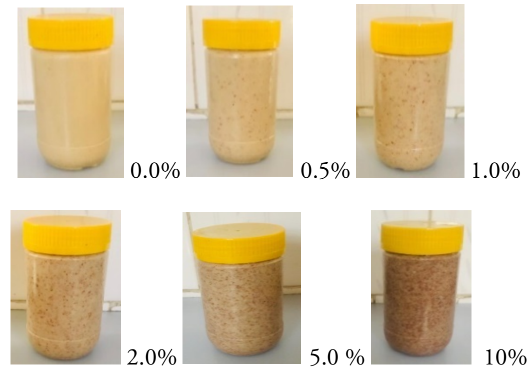

Figure 1. Sesame butter samples stabilized with different concentrations (%) of PS

3.2 Oil Separation

The influence of peanut skin (PS) concentration on oil separation is depicted in Figure 2. The figure illustrates the volume of oil separated from sesame butter samples containing varying PS concentrations over the storage period. As observed, the volume of oil separation generally decreased with increasing PS concentration levels and storage time.

Sesame butter samples fortified with PS concentrations of 2.0%, 5.0%, and 10.0% exhibited a pronounced stabilizing effect, as evident from the graph in Figure 2. This effect efficiently countered oil migration from the butter to the sample surface. Notably, no oil separation was observed in sesame butter samples stabilized with 2.0%, 5.0%, or 10.0% PS after 56 days of storage. These findings suggest that PS concentrations exceeding 2.0% were effective in preventing oil separation in sesame butter.

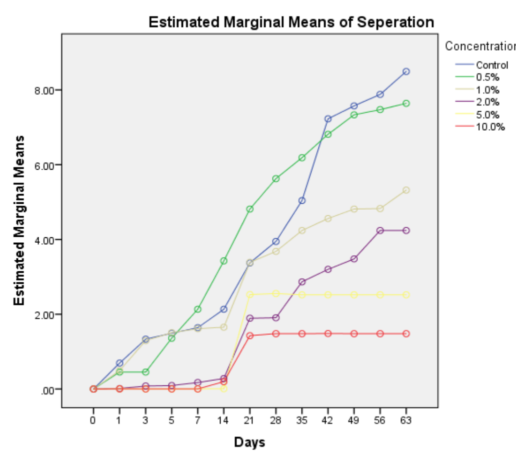

Figure 2. Percentage volume of oil separated at different concentrations over time (days)

On the contrary, PS concentration of 0.5% and 1.0% were not very effective in reducing oil separation compared to the control.

3.3 Sensory evaluation

The influence of peanut skin (PS) concentration on consumer perception of sesame seed butter sensory attributes is depicted in Figure 3 (Panels a-d). As observed, increasing PS concentrations generally compromised the product's texture, flavor, appearance, and overall acceptance scores. Figure 3a illustrates the negative correlation between PS concentration and texture scores. Sesame butter samples supplemented with 5.0% and 10.0% received the lowest scores, indicating extreme dislike due to a perceived non-smooth and stiff texture attributed to the increased PS levels. Conversely, the sample with the most favorable texture evaluation (score of 18) contained only 0.5% PS. This was followed by the samples with 1.0% PS (score of 14) and the control (score of 7). These findings suggest that panelists generally preferred the creamy and smooth texture associated with lower PS concentrations.

Similar to texture, flavor scores (Figure 3b) exhibited a declining trend with increasing PS content. Sesame butter samples containing 2.0% and below received high acceptability scores, indicating an extremely liked roasted nutty flavor. Notably, the sample with 1.0% PS achieved the highest score (13), followed by those with 2.0%, 0.5%, and 0% PS (scores of 12, 12, and 9, respectively). Conversely, samples with high PS concentrations (10% and 5.0%) were extremely disliked (scores of 13 and 9, respectively) due to an excessive burnt peanut flavor imparted by the PS. Figure 3c demonstrates the negative impact of PS concentration on the perceived appearance of the sesame butter. Samples with 1.0% PS received the highest score (15), indicating extreme liking, while those with 10.0% PS were extremely disliked (score of 27). Panelists favored the appearance of sesame butter containing lower PS levels (below 2.0%) due to their appealing light to moderate brown color, which aligns with consumer expectations for this product. Conversely, the increased particulates from higher PS concentrations (above 2.0%) resulted in a very dark brown color that was perceived as unappealing and potentially indicative of burning.

The consumer test results for overall acceptability (Figure 3d) mirrored the trends observed for individual sensory attributes. Sesame butter stabilized with 1.0% PS achieved the highest overall score, followed by those with 0.5% PS and the control. These findings corroborate the notion that consumer acceptance generally declines with increasing PS concentration in sesame seed butter.

Analysis of sensory evaluation data from Table 1 revealed no significant influence ($p = 0.975$) of sesame butter sample texture on overall consumer preference. Conversely, formulation, flavor, and color exerted significant effects ($p = 0.01$, $p = 0.001$, and $p = 0.001$, respectively) on overall consumer preference.

4 Discussion

Oil separation during storage is a major concern for sesame butter producers as it negatively impacts both product quality and consumer acceptance (Yuzer and Genccelep, 2024). This separation leads to the formation of a non-smooth texture, potential container contamination, reduced marketability and negatively affects acceptability by consumers (Al-Mahasneh et al., 2016). Consequently, preventing or minimizing oil separation is crucial for enhancing sesame butter's quality attributes, facilitating proper consumption, and potentially contributing to economic benefits (Yuzer and Genccelep, 2024). PS represent a valuable waste product with the potential to act as a natural stabilizer, minimizing phase separation and improving consumer acceptance in various food applications (Barrionuevo et al., 2020; Hamed et al., 2020). The present study investigated the effect of PS concentration on oil separation in sesame butter. Our findings revealed a positive correlation between PS concentration and its stabilizing effect. Low levels of PS addition resulted in improved quality attributes, particularly appearance and texture. However, high PS concentrations led to undesirable changes in these same attributes. In conclusion, incorporating a small quantity of PS into sesame butter offers a promising approach to minimize oil separation, enhance key quality attributes, and ultimately improve consumer acceptance of the product.

The addition of PS to sesame butter at varying concentrations, demonstrated significant differences in its ability to prevent oil separation. Control samples exhibited the highest degree of oil separation while those fortified with 10.0% PS displayed the least

Table 1. Tests of between-subjects effects on overall acceptance of sesame butter samples

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1971.980 [a]	204	9.667	9.105	.000
Formulation	16.996	5	3.399	3.202	.010
Texture	2.263	8	283	.266	.975
Flavor	92.954	8	11.619	10.944	.000
Color	55.789	8	6.974	6.569	.000

[a] R Squared = .951 (Adjusted R Squared = .847). Dependent Variable: Acceptance. Interactions were not significant

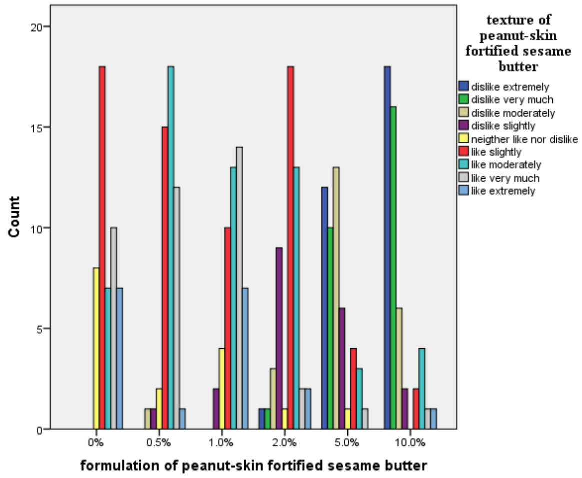

Figure 3a - Texture

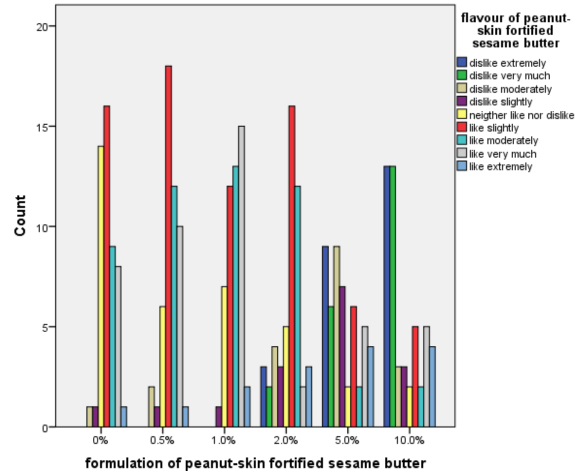

Figure 3b - Flavor

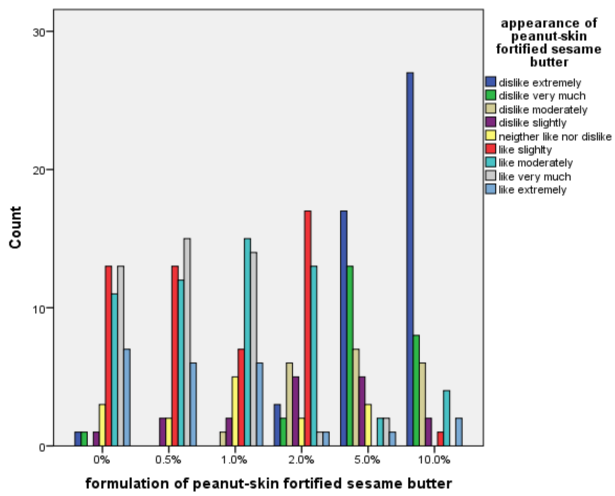

Figure 3c – Appearance

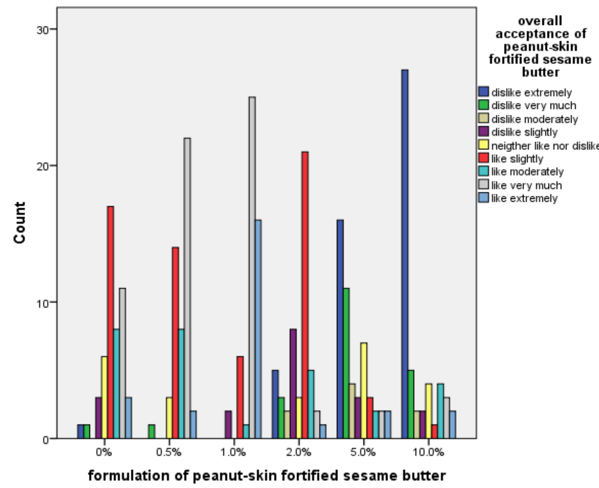

Figure 3d – Overall acceptance

Figure 3. Sensory evaluation responses for texture, flavor, appearance and overall acceptance of peanut-skin fortified sesame butter

amount of separation. In a related study, Barrionuevo et al., (2020) investigated the effect of incorporating 0.2g/100g of polyphenolic PS on the chemical and sensory properties of frankfurter-type sausages during storage. The study revealed that frankfurter sausage samples stored for 37 days with PS incorporated had less chemical deterioration caused by oil separation and oxidation compared to control (Barrionuevo et al., 2020). All sausages treated with 0.2g/100g PS had less chemical deterioration which was signified by good color, flavor and texture of the samples. The results align with those from this study as low addition of PS to sesame butter managed to reduce oil separation although it was to a lesser extent compared to the control. This reduction in oil separation likely contributed to the maintenance of good quality attributes (color, flavor, and texture) in the PS-fortified sesame butter.

Hamed et al., (2020) investigated the effect of fortifying yoghurt with PS extract on its antioxidant activity and various quality characteristics during cold storage. Their findings demonstrated that PS incorporation reduced syneresis, a phenomenon similar to the observed reduction in phase separation within sesame butter fortified with PS in the present study. This concordance suggests a potential underlying mechanism. The high fiber and antioxidant content of PS might act as stabilizing agents in both yogurt and sesame butter, hindering oil separation and promoting a more homogenous texture in the final products.

Sensory evaluation, a crucial tool for understanding product quality and consumer preference (Saleh and Lee, 2023), was employed to assess the textural and flavor attributes of sesame butter. Food texture, a vital element often overshadowed by taste and flavor, significantly influences consumer perception and consumption (Kamei et al., 2024). The results revealed a negative correlation between PS concentration and texture scores. Sesame butter sample with 0.5% and 1.0% PS, along with the control, received the highest texture scores, likely due to their creamy and smooth consistency. This favorable texture might be attributed to the low PS content, which maintained the inherent appeal of the sesame butter while introducing a subtle nutty and roasted flavor characteristic of peanuts. Conversely, samples containing 5.0% and 10.0% PS exhibited significantly lower texture scores due to a drier consistency and a grainier mouthfeel. Previously, consumer focus acceptance tests for butters have identified stiffness and thickness as negative attributes and these might have also led to consumers disliking samples with high levels of PS incorporation (Sanders et al., 2014). Flavor plays an important role in the selection and acceptance of food. The flavor scores of sesame butter decreased with the increase in the level of PS. Sesame butter with PS concentrations below 2.0% received high acceptance levels due to low levels of PS that imparted a mild nutty flavor and did not alter or overpower the taste of sesame butter. On the contrary, sesame butter samples with 10% PS had the highest dislike score, followed by samples with 5.0% and 2.0% PS. Panelists disliked the samples with high PS levels because the PS overpowered the mild and delicate flavor profile of the sesame butter. The high levels of PS also result in bitterness or astringency, commonly associated with the phenolics that are found in PS. In peanuts, increases in bitterness and astringency correlate negatively with consumer liking thus the reason for panelists disliking samples with 2.0%, 5.0% and 10.0% PS (Sanders et al., 2014).

Hathorn and Sanders, 2012 investigated the influence of fortifying peanut butter with PS on its flavor profile. Their sensory analysis yielded results similar to those observed in the present study. In both investigations, the addition of 1% PS did not elicit significant changes in the flavor attributes of the nut butter. This concordance may be attributed to the low concentration of PS, which likely remained below the sensory detection threshold of the panelists. However, incorporating 10% PS resulted in significant differences in most of the flavor sensory attributes towards more negative flavor. This is because at higher levels of incorporation particularly at 10 %, the bitter and astringent taste of the peanut skins became more distinctive and could be perceived by the panelists (Hathorn and Sanders, 2012).

The visual appearance of food products, including butters plays a significant role in quality perception as it can influence expectations of flavor and aroma (O'Keefe and Wang, 2006). The present study revealed a negative correlation between PS concentration and consumer acceptance of sesame butter appearance. Sesame butter samples with 1.0% level of PS received the highest appearance scores, indicating a strong preference for this visual characteristic. Conversely, samples containing 10.0% PS were rated extremely low in terms of appearance. Panelists generally favored the appearance of sesame butter with PS level below 2.0%. This preference can likely be attributed to the subtle visual enhancement and unique character imparted by low PS concentrations, without significantly altering the natural light to moderate brown color of sesame butter. The characteristic golden-brown color associated with sesame butter results from melanin production during the Maillard reaction and is often linked to desirable flavors and aromas. In contrast, darker colors, as observed in samples with high PS levels, can be associated with burnt flavors, potentially leading to negative consumer perception. (Sanders et al., 2014).

Results for overall acceptability obtained in the current study showed that sesame butter with 1.0% PS exhibited higher consumer acceptance scores compared to all other PS incorporated samples. This is because at low levels of incorporation, the PS imparted a roasty and nutty flavor characteristic of peanuts. A bitter and astringent taste was not perceived by the panelist. Similarly, a study conducted by Sanders et al., (2014) indicated that peanut butters with PS incorporated at levels below 3.75% had an overall good acceptability to consumers. Results of the study showed that addition of PS to peanut butter at levels above 3.75% resulted in a significant reduction ($p < 0.05$) in the acceptability with respect to appearance, flavor, texture and overall acceptability. Incorporating 2.5g peanut skins per 100g peanut butter (2.5% PS incorporation), produced peanut butter with an overall acceptability that equaled the control (Sanders et al., 2014). Incorporation of 2.5% PS was higher than the level of incorporation (1%) that was acceptable in sesame butter in the current study. This disparity might be attributed to the inherent flavor profiles of the nut butters. Sesame butter possesses a milder flavor compared to peanut butter. Consequently, incorporating PS into sesame butter resulted in a more pronounced alteration of most of the sensory attributes. Conversely, the robust and distinctive peanut flavor of peanut butter masked the sensory impact of PS incorporation to a greater extent, allowing for a higher acceptable PS level (2.5%). In contrast, peanut butter with 5.0g peanut skins/ 100g peanut butter (5% PS incorporation) were less acceptable compared to other formulations in that previous study (Sanders et al., 2014). At such high incorporation levels, the characteristic peanut flavor was likely overpowered by the bitter and astringent taste profile associated with PS. The results are comparable to those of the current study as it was noted that at higher levels of PS skin incorporation (5% and above) the sesame butter was less acceptable. At such levels of incorporation, the peanut skins might have failed to complement the flavor profile of sesame butter.

Sesame butter samples containing 5.0% and 10.0% of PS exhibited significantly lower scores for appearance, flavor, and texture. Panelists found these formulations extremely dislikable, likely due to the presence of a bitter aftertaste and the increased visibility of particulates associated with high PS incorporation levels. These findings align with previous research by Mcneill et al. (2000) and Ma et al. (2014) who demonstrated a decline in consumer acceptance of butters containing visible particulates. Overall acceptability mirrored the trends observed for individual sensory attributes, with high PS levels (5.0% and 10.0%) resulting in significantly lower consumer preference. A related study by Ma et al. (2012) reported that peanut butter formulations containing PS below 3.75% maintained color and spreadability comparable to the control. In the present study, consumer acceptance of sesame butter texture and color exhibited a clear concentration-dependent decrease with increasing PS fortification. Acceptable level of PS incorporation of 3.75% or lower for peanut butter as reported by Ma et al. (2012) is slightly higher than the 1% in the current study. This is mainly due to the fact that sesame butter has a lighter color as well as a smoother and creamier texture compared to peanut butter. As a result, the addition of slightly higher levels of PS in peanut butter had no effect on the color and texture as they blended well (Ma et al. 2014). Conversely, the same PS levels resulted in a darker appearance and a grainy/rougher texture in sesame butter due to the lighter base color and smoother starting texture.

Table 1 presents the results of the statistical analysis, with an $R^2 = 0.951$. This strong correlation coefficient (R^2) indicates a robust fit for the model employed to assess the relationship between formulation factors and overall sesame butter acceptability. The findings suggest that formulation, flavor, and color are significant determinants of consumer preference for sesame butter.

Low-level PS incorporation offers a promising strategy to address two key challenges in sesame butter production: oil separation during storage and consumer acceptance. By mitigating oil separation, PS can contribute to a more stable and visually appealing product. Furthermore, the growing consumer interest in natural preservatives such as PS, driven by their perceived health benefits, presents an opportunity to leverage PS as an acceptable and functional ingredient in sesame butter formulations.

5 Conclusion

This study investigated the effect of peanut skin (PS) concentration on oil separation in sesame seed butter. The results demonstrated a decreasing trend in oil separation with increasing PS content. Sesame butter fortified with 1.0% PS exhibited the highest level of consumer acceptance among the tested formulations. However, consumer acceptability scores declined with PS concentrations exceeding 1.0% These findings suggest the potential application of PS as a natural stabilizer to prevent oil separation in sesame butter. Furthermore, incorporating PS into sesame seed butter offers the potential to diversify product lines within the sesame product category, while also providing an alternative for consumers with peanut allergies who seek similar seed-based spreads. Additionally, this research may contribute to the peanut industry by identifying a valuable application for PS waste products, promoting resource utilization and potentially reducing waste generation.

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