

Proximate composition and sensory evaluation of local pumpkin spread incorporated with dark chocolate

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ARTICLE HISTORY

Received : 19 July 2025

Accepted : 3 February 2026

Online : 30 September 2026

KEYWORDS

physicochemical,
pumpkin fruit spread,
chocolate fortification,
consumer acceptance

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ABSTRACT

This study investigates the impact of incorporating dark chocolate into pumpkin spread on its proximate content and consumer acceptance. Four formulations of pumpkin spread were developed using pumpkin puree, allulose, dark chocolate and maple syrup. The samples were analyzed for their proximate composition and sensory evaluation. The four treatments consisting of Control sample (0% dark chocolate), F1 (5% dark chocolate), F2 (10% dark chocolate), and F3 (15% dark chocolate) were analyzed statistically ($p < 0.05$) using ANOVA and Post-hoc analysis. Proximate analysis revealed significant increases in protein content from $0.79 \pm 0.03\%$ in the control to $5.71 \pm 0.01\%$ in F3, and fat content from $0.06 \pm 0.01\%$ in the control to $0.41 \pm 0.14\%$ in F3. Sensory evaluation was conducted by 60 semi-trained panelists using a 9-point hedonic scale revealed that formulations with 10% and 15% dark chocolate were significantly preferable for appearance ($7.02 \pm 1.45; 7.06 \pm 1.48$), colour ($7.17 \pm 1.32; 7.25 \pm 1.28$), texture ($7.03 \pm 1.39; 6.75 \pm 1.27$), aroma ($6.23 \pm 1.83; 6.43 \pm 1.95$), and overall taste ($7.17 \pm 1.32; 7.25 \pm 1.28$) compared to the control. These findings suggest that incorporating dark chocolate into pumpkin spread not only enhances its sensory appeal but also improves its nutritional profile by moderately enhancing its nutrients content specifically ash, protein, fat and fibre. This study provides valuable insights into the development of novel and healthier pumpkin-based products with enhanced consumer acceptability using a sustainable tropical agricultural resource.

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1. INTRODUCTION

Pumpkin (*Cucurbita* spp.), a member of the Cucurbitaceae family, is a widely cultivated tropical crop valued for its nutritional content and functional food potential (Hagos et al., 2022). Rich in fibre, vitamins, essential fatty acids, and antioxidants such as β -carotene, vitamin E, and carotenoids, pumpkins are increasingly recognized for their health benefits (Batool et al., 2022; Dotto & Chacha, 2020). Despite its abundance in Malaysia, especially in states like Johor, Kelantan, and Terengganu, the use of pumpkin in value-added functional foods remains limited (DOA, 2024; Kamarubahrin et al., 2019).

Pumpkins flesh or pureed are nutritious, well known for supporting eye health, immunity, digestion, and

cardiovascular function. They are rich in beta-carotene, a bioactive compound that will be converted into vitamin A by the body. They also support corneal health and vision, help protect against oxidative stress and inflammation, and may reduce the risk of chronic diseases linked to oxidative damage, including certain cancers and heart conditions (Ceclu et al., 2020; Aldakhoul et al., 2024). They also provide dietary fibre, potassium, vitamin C, and vitamin E, which collectively improve gut motility, lower blood pressure, enhance immune function, and contribute to skin health (Anitha et al., 2025).

Pumpkin spreads, particularly those formulated from *Cucurbita* seeds and pulps, are gaining attention as novel functional food products due to their rich nutritional profiles and favorable sensory attributes. Recent studies

demonstrated that pumpkin seed spreads exhibit promising physicochemical and sensory properties when different oil types are incorporated; for example, blends with palm and olive oil significantly enhanced spread ability and consumer acceptance, underscoring the importance of formulation on texture and overall quality (Baharudin & Kormin, 2025; Dotto & Chaca, 2020). Optimization studies using response surface methodology have further identified specific oil and sweetener ratios that improve textural metrics and consumer preference, pointing to the applicability of systematic formulation design in commercial spread development (Saydam, Önal, & Bıçak, 2025). Collectively, these findings suggest that pumpkin spreads not only leverage underutilized seed biomass, but also align with modern nutritional trends, offering functional benefits alongside desirable sensory profiles.

Besides, commercially available pumpkin spreads are often formulated with added sugar to improve taste, yet this raises health concerns related to obesity, diabetes, and other non-communicable diseases (Stanner & Spiro, 2020). Attempts to reduce sugar content may compromise consumer acceptance due to changes in sweetness and texture (Nduko et al., 2018). To address this issue, allulose is used to substitute white sugar. Allulose is a low-calorie rare sugar with approximately 70% of the sweetness of sucrose that effectively reproduces sucrose's bulking and textural roles in food matrices. Its functional properties, including enhanced Maillard browning and moisture retention, may improve spreadability, texture, and flavour release in chocolate–pumpkin systems (Food Standards Australia New Zealand, 2023). Together, the lipid-rich dark chocolate and the low-glycemic allulose may yield a spread with enhanced sensory richness and a lipid profile more aligned with modern health trends (lower added sugar, balanced fatty acids), thus addressing consumer demand for indulgent yet reduced-sugar spreads (Mokhtar et al., 2025).

Incorporating dark chocolate into pumpkin-based spreads can enhance both sensory appeal and lipid composition, creating a functional food product that leverages the rich phenolic profile of cacao alongside the nutritional matrix of pumpkin seeds. Dark chocolate, characterized by high cocoa content and significant polyphenol and unsaturated fat levels, contributes complex flavor notes (bitterness and cocoa intensity) and desirable mouthfeel in spreadable products, effects that are critical determinants of consumer sensory acceptance (sensory descriptors such as texture, flavor, and spread ability are key in chocolate spread evaluations) and may interact synergistically with the nutty, mildly sweet profile of pumpkin seed components (Amoah et al., 2023). Besides, dark chocolate is recognized for its antioxidant capacity and sensory richness, which has been proposed to improve both the palatability and nutritional profile

of reduced-sugar pumpkin spreads (Toker et al., 2020).

To substantiate the nutritional value of this functional food, the present study investigates the proximate composition and sensory properties of a pumpkin-based spread fortified with dark chocolate and formulated with allulose as a sugar substitute. By examining this novel formulation, the study contributes to the development of sustainable, health-oriented food products that effectively value tropical agricultural resources.

2. MATERIALS AND METHODS

2.1 Source of raw materials

The raw materials were used including pumpkin, dark chocolate (100% cocoa powder with less than 20% butter, brand Van Houten, Netherland), food grade allulose (Nutrition profile: 1% carbohydrate, 0% fat, 0% protein, 0% fibre, brand: HMVS, Australia), sugar-free maple syrup (Nutrition profile/100g: Energy: Energy 51 Cal, Protein 0g, Fat 0g, Sorbitol 14.5g, Dietary fibre <1g, Sodium 200mg, brand: Queen, Canada), and lime were purchased from supermarket at Nilai, Negeri Sembilan.

2.2 Chemical lists

All chemicals and reagents used in this study were of analytical grade. Instrument calibration was performed using certified calibration standards prior to analysis and verified at regular intervals in accordance with the manufacturer's recommendations to ensure analytical accuracy and reliability. The analytical grade chemicals that were used to perform the analysis included Methanol (Merck, Germany), sodium hydroxide solution (R&M Chemicals, United Kingdom), (5% w/v) sodium nitrate solution (R&M Chemicals, United Kingdom), (10% w/v) aluminum chloride, (R&M Chemicals, United Kingdom) concentrated sulfuric acid (H₂SO₄) (Chemiz, Malaysia), kjedahl tablet (Chemiz, Malaysia), petroleum ether (Chemiz, Malaysia), Caustic Soda (NaOH) Solution (R&M Chemicals, United Kingdom), Boric Acid Solution (2%) (R&M Chemicals, United Kingdom), Hydrochloric Acid (HCl) Solution (Chemiz, Malaysia), Potassium Hydroxide solution (KOH), which were prepared by the laboratory at the Faculty of Science and Technology, Universiti Sains Islam Malaysia.

2.3 Determination of dark chocolate pumpkin fruit spread acceptance through preliminary study

A preliminary study was conducted to determine the acceptance of a dark chocolate-fortified pumpkin spread. Four formulations were developed, comprising one control (0% dark chocolate) and three experimental variants containing 5%, 10%, and 15% dark chocolate (designated as F1, F2, and F3, respectively). Sensory evaluation was performed by ten (10) semi-trained panelists drawn from the Food Biotechnology programme at Universiti Sains Islam Malaysia.

The sample size employed at this preliminary stage is consistent with standard practices in sensory and functional food product development, allowing effective formulation screening prior to larger-scale consumer testing and shelf-life evaluation (Caponio et al., 2020; Samanta et al., 2022b). As the primary objective of this preliminary study was to assess panelist acceptance and guide formulation selection, inferential statistical analysis was not conducted.

Table 1: Formulation of pumpkin fruit spread incorporated with dark chocolate

Ingredients	Control (%)	Formulation A (%)	Formulation B (%)	Formulation C (%)
Pumpkin puree	49	43	36	29
Allulose	42.4	42.4	42.4	42.4
Dark Chocolate	-	5	10	15
Sugar-free maple syrup	8.6	9.6	11.6	13.6

Note: This formulation was designed based on preliminary studies involving 10 people.

2.4 Preparation of pumpkin spread

Pumpkin spread was prepared according to common fruit-spread recipe with slight modifications. The pumpkins were diced into small chunks. Pumpkin slices were placed in a steamer basket inside a pot of water. Then, the water was boiled, and it continued to cook until the pumpkins were extremely soft and tender. Once cooked, any excess water was drained, and pumpkins were allowed to cool completely. After cooling, the peels were removed using a spoon to scoop the flesh of the pumpkin and scrape apart the stringy inners of the pumpkin. Then the pumpkin was blended until smooth. All the ingredients such as pumpkin puree, allulose, dark chocolate, and sugar-free maple syrup were added into the pot on medium-high heat, and the ingredients were stirred together. The pumpkin mixture was cooked for about 15-20 minutes and was stirred regularly. Finally, the spread was transferred to a clean and airtight container. After the spread was completely cooled, the mixture was refrigerated.

2.5 Determination of proximate composition

The pumpkin spread samples were subjected to analysis for moisture, total protein, fat, ash, fibre, and total carbohydrate using standard AOAC procedures (AOAC International, 2023), with all measurements performed in triplicate (n = 3) to ensure reproducibility.

2.5.1 Moisture content

The moisture content of the pumpkin spread samples were assessed through oven-drying at 105°C (AOAC International, 2023). The samples weighed about 5g and the weight was recorded. The samples were placed in a crucible, weighed, and the weight was recorded. The crucibles were placed in the drying oven overnight. The final weight was calculated, and the moisture content was determined by subtracting the final weight of samples with crucible and the

initial weight of samples with crucible.

$$\text{Moisture \%} = [(W_1 - W_2) / (W_1 - W_0)] \times 100$$

Where:

W₀ = weight of empty moisture dish (g)
W₁ = weight of dish + sample before drying (g)
W₂ = weight of dish + sample after drying (g)

2.5.2 Protein content

The total protein content was analyzed by the Kjeldahl method and by using the conversion factor 6.25 to convert it into percent of crude protein (AOAC International, 2023). There were three stages of process for protein analysis which are digestion, distillation and titration using vapodest 500°C Kjeldahl Analyzer. The samples weighed about 2g, and the weight was recorded. The samples then were transferred into a digestion flask. A 20 mL of concentrated sulfuric acid (H₂SO₄) and kjeldahl tablet were put in the flask. The Kjeldatherm/Turbotherm digestion system or flask heater was used to heat the mixture until it becomes translucent. After cooling and fuming neutralization, the vapodest distillation unit separated the ammonia gas into a boric acid solution receiver. The ammonia content was determined by titration with standard hydrochloric acid solution using an indicator or pH meter. A blank determination with only chemicals was performed to account for background.

$$\text{Protein \%} = [(V_{\text{sample}} - V_{\text{blank}}) \times N_{\text{HCl}} \times 14.01 \times 6.025] / W_{\text{sample}}] \times 100$$

Where:

V_{sample} = volume of acid used for titration of sample (mL)
V_{blank} = volume of acid used for blank (mL)
N_{HCl} = normality of titrant (mol/L)
W_{sample} = sample weight (g)
14.01 = atomic weight of nitrogen (g/mol)
6.025 = Nitrogen-to-protein conversion factor (6.25 for general foods)

2.5.3 Crude fat content

The pumpkin spread samples were analyzed for their crude fat content by using continuous extraction in a Soxhlet apparatus and using hexane as the solvent (AOAC International, 2023). A 4 g of samples were added to the thimble. Flask and boiling stone used were also weighed and recorded. Then, boiling stone, sample with thimble and glass wool were put into the flask. Next, the flask was filled with 120 ml of Petroleum ether. The flask was then put in the Soxhlet apparatus, and the extraction took about 6 hours. After drying in a drying oven for approximately 4 hours, the flask and its contents were undergoing weighing. Following cooling in a desiccator, the fat content of the pumpkin samples was determined using the provided equation.

$$\text{Fat (\%)} = [(W_2 - W_1) / W_s] \times 100$$

Where:

W₁ = weight of empty, clean extraction flask (g)
W₂ = weight of flask after extraction and drying (g)
W_s = weight of sample (g)

2.5.4 Ash content

The total ash content of the pumpkin spread samples was analyzed by the gravimetric method of incineration in a muffle furnace at 550° C (AOAC International, 2023). Samples weighed around 3g and the weight was recorded. Empty crucible was weighed and recorded. The samples put in a crucible were burned on an electric hot plate in a fume cupboard until there was no smoke coming out of the samples. After the samples being cooled down using desiccator, the samples were put in the muffle furnace and were ignited at 550° C overnight. The muffle furnace was turned off when the temperature dropped to 250°C. The crucible was taken out slowly to avoid losing any ash and was cooled using desiccator. The samples with the crucible were weighed and the weight was recorded. The percentage of the crude ash was calculated by using the equation:

$$\text{Crude ash (\% dry basis)} = (W_2 - W_0 / W_1 - W_0) \times 100$$

Where:

W_0 = weight of empty crucible (g)

W_1 = weight of crucible + sample before ashing (g)

W_2 = weight of crucible + ash after incineration (g)

2.5.5 Crude fibre content

Crude fibre content was determined using a gravimetric method according to AOAC procedures, employing a Fibretherm system (Fibretherm, Gerhardt GmbH, Germany). The pumpkin spread sample was finely ground, and approximately 1.0 g of the sample was accurately weighed and recorded. The weighed sample was transferred into a digestion vessel and subjected to acid digestion using 1.25% (w/v) sulfuric acid (H_2SO_4) under controlled heating conditions. Following boiling, the digested mixture was filtered through a crucible fitted with a fibreglass filter to separate the insoluble residue. The residue was thoroughly washed with hot distilled water to remove residual acid and soluble components. Subsequently, the crucible containing the residue was dried in a drying oven at a specified temperature until constant weight was achieved, cooled in a desiccator to prevent moisture uptake, and weighed. Crude fibre content was calculated as a percentage of the original sample weight in accordance with AOAC International (2023).

$$\text{Crude Fibre \%} = [(W_2 - W_3) / W_1] \times 100$$

Where:

W_1 = weight of dried sample (g)

W_2 = weight of crucible + residue after digestion and drying (g)

W_3 = weight of crucible + ash after incineration (g)

2.5.6 Carbohydrate content

Total carbohydrate content was calculated by difference according to AOAC procedures, subtracting the sum of moisture, crude protein, crude fat, and ash contents from 100%. The equations are as follows:

$$\text{Carbohydrates \%} = 100\% - [\text{moisture \%} + \text{ash \%} + \text{protein \%} + \text{fat \%}]$$

2.6 Sensory evaluation test

Affective tests using hedonic scales were used to assess consumer response, mainly on their preference or acceptance. The Hedonic Test with 9-point scale was used in measuring food acceptability for consumers and facilitates the application of parametric statistical methods, such as analysis of variance (ANOVA), to discern statistically significant disparities between products. For this test, 60 semi-trained panelists male and female panelists aged between 20 to 30 years old from Program of Food Biotechnology, Universiti Sains Islam Malaysia were involved in conducting this sensory test. Sample serving order, randomization, and presentation temperature were at room temperature during the evaluation. The panelists were given four pumpkin spreads with different formulations and one control sample. All samples were coded with a three-digit random code number for randomization. The panelists compared the attributes of the samples in terms of appearance, colour, texture, aroma, taste and were recording the results on score sheets given. Bread was served along with pumpkin spread samples as a carrier. The consent form to conduct the sensory analysis was in accordance with the protocol approved by the University Ethics Committee UniSZA/UHREC/2023/514.

2.7 Statistical analysis

Statistical analysis was performed using MetaboAnalyst 6.0 software. Data normality was assessed using the Shapiro–Wilk test, while the homogeneity of variances was evaluated using Levene's test. For data that met the assumptions of normality and homogeneity, differences among means were analyzed using one-way analysis of variance (ANOVA). When significant differences were detected ($p < 0.05$), post-hoc multiple comparison tests were conducted using Tukey's Honestly Significant Difference (HSD) or Duncan's multiple range test to identify specific differences between sample means.

3. RESULT AND DISCUSSION

3.1 Preliminary study of pumpkin spread acceptance

Table 2 shows the result of acceptance of pumpkin spread incorporated with dark chocolate through preliminary study. From this table, it shows that the most preferable formulation was Formulation B. In this study, a preliminary formulation trial was essential to identify the acceptance level of dark chocolate incorporation into pumpkin spread while maintaining nutritional quality and sensory appeal. This early-phase testing minimized resource use and enabled the adjustment of ingredient ratios to ensure the product met desirable consumer expectations in terms of appearance,

texture, aroma, and flavour (Caponio et al., 2020).

Preliminary studies also play a critical role in assessing the compatibility of functional ingredients, such as dark chocolate and allulose, to ensure a stable and appealing final product (Samanta et al., 2022a). Furthermore, this phase supports innovation by allowing the integration of health-focused components, such as sugar substitutes and antioxidants, in response to consumer demand for development by narrowing down the best formulations for detailed nutritional and sensory analysis, while also reducing production costs and enhancing consumer satisfaction. The preliminary sensory evaluation indicates an overall positive acceptability of the dark chocolate-fortified pumpkin spread, particularly for Formulations B and C. Based on the degree of likeness, a higher proportion of respondents rated Formulation B (65%) and Formulation C (64%) within the “like” category (scores 6–9) compared to Formulation A (50%). This suggests that modifications applied in Formulations B and C were more successful in meeting consumer sensory expectations. Notably, Formulation B recorded the lowest percentage of disliked responses (17%), indicating a more favourable balance of sensory attributes among the formulations tested.

Formulation A exhibited a comparatively higher proportion of neutral and disliked responses, which may suggest that its formulation parameters, such as sweetness intensity, cocoa concentration, or texture, were less optimal. The higher acceptability observed in Formulations B and C may be attributed to improved flavour harmony between dark chocolate and pumpkin components, as well as enhanced textural properties that contributed to better spreadability and flavour release. Although Formulation C showed a slightly higher dislike percentage than Formulation B, its strong “like” response suggests that it remains a promising formulation.

Overall, these findings demonstrate that the dark chocolate-fortified pumpkin spread is generally acceptable to respondents, with Formulation B showing the most favourable preliminary consumer response. However, as this assessment was conducted with a limited number of respondents ($n = 10$), further sensory evaluation involving a larger consumer panel and comprehensive preference analysis was conducted to confirm acceptability and guide final formulation optimization for further step of formulation in future.

Table 2: Preliminary study of pumpkin fruit spread incorporated with dark chocolate acceptance

	Formulation A	Formulation B	Formulation C
Scores 1-4 (Dislike)	25%	17%	28%
Score 5 (Neutral)	25%	18%	8%
Scores 6-9 (Like)	50%	65%	64%

The results presented indicate the degree (%) of likeness based on 10 respondents.

3.2 Proximate analysis

Proximate analysis, which evaluates moisture, ash, protein, fat, and carbohydrate contents, is essential for

assessing the nutritional value of food products (AOAC International, 2023). This study analyzed the nutritional composition of pumpkin chocolate spreads with varying dark chocolate levels, as detailed in Table 3, to understand how formulation impacts overall nutrient content.

3.2.1 Moisture content

The inclusion of dark chocolate in pumpkin-based spreads led to a gradual reduction in moisture content, though the decrease was not statistically significant across formulations ($p > 0.05$). Moisture levels dropped from $41.23 \pm 4.62\%$ in the control to $33.20 \pm 7.04\%$ in the formulation containing 15% dark chocolate. This trend is consistent with the significantly lower moisture content of dark chocolate, which typically contains $1.36 \pm 0.34\%$ moisture, compared to pumpkin flesh, which consists of approximately 84% water (Hussain et al., 2023). Dark chocolate is considered a low-moisture ingredient due to the conching and refining process that reduces water content to below 2% (Aidoo et al., 2013). Consequently, increasing the proportion of chocolate in formulations contributes to lower overall moisture content. This compositional change may not be statistically significant, but the directional trend has practical implications for product stability and quality.

Lower moisture content enhances microbial stability by reducing water activity (a_w), which is a critical parameter in limiting microbial growth. Foods below 0.6 are generally considered shelf-stable (Bolarinwa et al., 2020). Thus, chocolate-enriched spreads may exhibit improved shelf life due to reduced water activity. However, moisture reduction also impacts sensory and rheological properties. Lower moisture levels can increase firmness, reduce spread ability, and affect flavour release, particularly in fat-based systems like chocolate spreads (Ahmed et al., 2021; Rifna et al., 2022). Even though there is positive effect in terms of reducing microbial growth due to the low moisture content in this product, optimizing moisture content is vital for balancing its shelf stability and consumer acceptability.

3.2.2 Protein content

The incorporation of dark chocolate significantly elevated the protein content of the pumpkin-based spreads: F1 recorded $2.64 \pm 0.01\%$, F2 reached $4.24 \pm 0.01\%$, and F3 attained $5.71 \pm 0.01\%$, all of which were substantially higher than the control formulation ($0.79 \pm 0.03\%$), with the differences being statistically significant ($p < 0.05$). This increase is attributable to the comparatively high protein content of dark chocolate, which typically ranges from 8.0% to over 20.0%. In contrast, pumpkin flesh contains only around 1.13% to 1.46% protein per 100 g, as reported in several compositional studies (Batool et al., 2022; Jaćimović et al., 2022a).

As higher percentages of dark chocolate were incorporated into the formulations, the total protein levels increased proportionally, reflecting the protein-dense nature of chocolate compared to pumpkin. This pattern of nutritional enhancement underscores the potential of dark chocolate as a fortifying ingredient in functional food applications, particularly in plant-based or health-focused spreads. Notably, protein enrichment contributes not only to improved nutritional values supporting satiety and muscle repair, but also aligns with consumer demand for enhanced-protein functional foods. Therefore, the use of dark chocolate in such formulations presents a practical and appealing strategy for enhancing the protein profile of pumpkin-based spreads.

3.2.3 Crude fat content

The inclusion of dark chocolate led to a significant increase in fat content in the pumpkin-based spreads. Formulation F2 had $0.32 \pm 0.06\%$ fat and F3 reached $0.41 \pm 0.14\%$, compared to the control ($0.06 \pm 0.01\%$) and F1 ($0.11 \pm 0.04\%$) ($p < 0.05$), with no significant difference between F1 and the control ($p > 0.05$). This increase is attributed to the richness of dark chocolate in lipids, containing approximately 30–50% fat with 99% cocoa dark chocolate containing up to 49g fat per 100g (Jaćimović et al., 2022b), and cocoa solids providing up to 43–67% lipids, with 99% cocoa dark chocolate containing up to 49 g fat per 100 g (Samanta et al., 2022).

In contrast, pumpkin flesh contains only around 1.09% fat per 100 g (Aziz et al., 2023; Hussain et al., 2023). The fat in dark chocolate is derived primarily from cocoa butter, which is rich in oleic (~33%), palmitic (~25%), and stearic (~33%) acids, contributing to its solid fat matrix (Samanta et al., 2022). As levels of dark chocolate increased from F1 to F3, the higher lipid content proportionally increased the overall fat content of the spreads, underscoring its significant impact on the nutritional profile even with modest additions. Moreover, cocoa butter is a unique vegetable fat rich in stearic acid, which has been shown to have a neutral impact on blood cholesterol levels. Unlike other saturated fats, its metabolic conversion to oleic acid allows it to be included in heart-healthy diets without the typical adverse effect on cardiovascular lipid profiles (Kris-Etherton et al., 1994; Hunter et al., 2010).

3.2.4 Ash content

Ash content in the pumpkin-based spreads rose steadily from $0.53 \pm 0.06\%$ in the control to $0.89 \pm 0.02\%$ (F1), $1.02 \pm 0.36\%$ (F2) and $1.45 \pm 0.05\%$ (F3) and the increase was statistically significant ($p < 0.05$). The pattern mirrors the escalating proportion of dark chocolate, an ingredient that typically contains about 1.5–2.1 % ash (mineral residue) in 70–99 % cocoa bars (Jaćimović et al., 2022b),

whereas raw

pumpkin flesh contributes only $\approx 1.0\%$ ash on a wet-weight basis (Hussain et al., 2023). Multi-element analyses of high-cocoa dark chocolates show concentrations of ranged between 230 mg Mg and 12 mg Fe per 100 g which is enough to supply 55–65 % of the adult daily value for magnesium and nearly 70 % for iron (Jaćimović et al., 2022). These data explain the progressive mineral enrichment observed as dark chocolate inclusion rose from F1 to F3, underscoring its usefulness for boosting the micronutrient density of pumpkin-based spreads.

Since ash represents the total mineral fraction, higher values indicate greater mineral fortification. Ash fortification can also improve the functional properties of fruit-based products by supplying inorganic elements that play roles in metabolic processes, making fortified fruit spreads potentially more valuable as functional foods in improving dietary mineral intake (Asare et al., 2022).

3.2.5 Fibre content

Although not statistically significant ($p > 0.05$), fibre content increased progressively with greater dark chocolate incorporation across the pumpkin-based formulations. The control sample recorded $0.84 \pm 0.00\%$, while F1, F2, and F3 showed $1.04 \pm 0.01\%$, $1.16 \pm 0.00\%$, and $1.17 \pm 0.01\%$ fibre content, respectively. This trend is consistent with the naturally high dietary fibre content of dark chocolate, which provides approximately 10–12 g of fibre per 100 g, mainly from insoluble cocoa husk and seed coat fibres (Caponio et al., 2020; Tan et al., 2021). In contrast, raw pumpkin pulp contains only about 0.42% fibre per 100 g (Hussain et al., 2023).

These cocoa-derived fibres comprising cellulose, hemicellulose, and lignin alongside other bioactive constituents are increasingly recognized for their functional properties, including the support of improved gut motility and favourable effects on glycemic and lipid metabolism (Jalil & Ismail, 2021; Tan et al., 2021). Thus, the inclusion of dark chocolate modestly enhances the nutritional value of pumpkin-based spreads by enriching them with dietary fibre, particularly beneficial in functional food applications targeting digestive health.

3.2.6 Carbohydrate content

Carbohydrate levels remained consistent across all formulations (ranged from 54% - 58%), with no statistically significant differences ($p > 0.05$). The control sample, containing 49 % pumpkin, exhibited $56.55 \pm 0.27\%$ carbohydrates, notably lower than the 81.24 % reported for pure pumpkin flesh. This expected discrepancy is likely caused by recipe composition, processing losses, or varietal differences (Gamage et al., 2023; Hussain et al., 2023). Despite dark chocolate contributing approximately 10%

carbohydrates per 100 g (Jaćimović et al., 2022b), its inclusion was balanced by a proportionate reduction in pumpkin, stabilizing overall carbohydrate content. Furthermore, the integration of allulose, a rare sugar, accounted for total carbohydrate content (FDA, 2020), influenced composition without altering glycemic load, contributing caloric value (~0.4 kcal/g) but maintaining uniform carbohydrate percentages (FDA, 2020). Thus, the consistent carbohydrate levels reflect compensatory adjustments between pumpkin, chocolate, and sweetener proportions within the formulation.

Table 3: Proximate analysis of pumpkin fruit spread incorporated with dark chocolate

Percentage (%)	Control	F1	F2	F3
Moisture	41.23 ± 4.62 ^a	40.00 ± 2.32 ^a	38.72 ± 1.78 ^b	33.20 ± 7.04 ^b
Ash	0.53 ± 0.06 ^a	0.89 ± 0.02 ^b	1.02 ± 0.36 ^b	1.45 ± 0.05 ^c
Protein	0.79 ± 0.03 ^a	2.64 ± 0.01 ^b	4.24 ± 0.01 ^c	5.71 ± 0.01 ^c
Fat	0.06 ± 0.01 ^a	0.11 ± 0.04 ^a	0.32 ± 0.06 ^b	0.41 ± 0.14 ^b
Fibre	0.84 ± 0.00 ^a	1.04 ± 0.01 ^b	1.16 ± 0.00 ^b	1.17 ± 0.01 ^b
Carbohydrate	56.55 ± 0.27 ^a	54.93 ± 0.27 ^b	54.54 ± 0.27 ^b	58.07 ± 0.27 ^a

The presented results are indicated as a means value ± standard deviation

Values with different superscript letters in a row indicate statistically significant within the group at level $p < 0.05$.

Notes: Control (100% pumpkin)

F1 (inclusion of 5% dark chocolate)

F2 (inclusion of 10% dark chocolate)

F3 (inclusion of 15% dark chocolate)

3.3 Sensory evaluation test

Sensory evaluation of the pumpkin chocolate spread formulations was conducted to assess appearance, colour, texture, aroma, and overall taste. This assessment offers important understanding of the product's consumer appeal and market viability by recording personal preferences and sensory experiences. The findings are summarized in Table 4, illustrating the influence of varying levels of dark chocolate on the sensory attributes.

3.3.1 Appearance

The addition of dark chocolate significantly enhanced the visual appeal of the pumpkin-based spread. Formulations F2 (7.02 ± 1.45) and F3 (7.06 ± 1.48), containing 10 % and 15 % dark chocolate respectively, received significantly higher appearance scores compared to the control (6.40 ± 1.84) and F1 (6.52 ± 1.63), indicating that increased chocolate content improved visual appeal ($p < 0.05$). The richer, darker hues and smoother texture of dark chocolate enriched the product's visual characteristics, which are strongly associated with attractiveness and quality perception (Spence & Velasco, 2018). Consumer research also shows that darker chocolate colours positively influence purchase intent and brand perception (Beneke et al., 2015; Steiner & Florack, 2023).

3.3.2 Colour

The formulations' colour intensity increased with the incorporation of dark chocolate. F2 (7.17 ± 1.32) and F3 (7.25 ± 1.28) received notably higher scores compared to the

control (6.67 ± 1.73) and F1 (6.32 ± 1.75) formulations. The deeper colour, resulting from a higher cocoa content in F2 (10% dark chocolate) and F3 (15% dark chocolate), was viewed as more appealing by the panelists, dark chocolate is recognized for its deep and vibrant hue, enhancing its image as a high-quality product as deep brown hues in chocolate are psychologically linked by consumers to "premium quality," "richness," and "indulgence" (Spence & Velasco, 2018). This alteration in colour can also impact consumer preferences, as individuals frequently link deeper colours with superior quality and flavour, particularly in items such as chocolate spreads, where colour serves as a crucial sign of cocoa content and richness.

3.3.3 Texture

The texture of the pumpkin–chocolate spread improved significantly with increased dark chocolate inclusion. Formulations F2 (10% dark chocolate) and F3 (15% dark chocolate) earned sensory scores of 7.03 ± 1.39 and 6.75 ± 1.27 , respectively which is significantly higher than the control (0%, 6.53 ± 1.58) and F1 (5% dark chocolate, 6.35 ± 1.49) ($p < 0.05$). This indicates that the added chocolate enriched the sensory texture of the spreads with creaminess and mouthfeel.

This effect can be attributed to the cocoa butter in dark chocolate: a natural fat that melts just below body temperature, creating a smooth, velvety texture and luxurious mouthfeel that enhances spreadability and cocoa butter's critical role in imparting chocolate its characteristic silky consistency and melt properties. Similarly, the sensory appeal and creaminess of chocolate-based products are fundamentally governed by a triacylglycerol composition of the fat phase. As noted by Afoakwa et al. (2007), the balance between solid and liquid triglycerides determines the network's ability to remain spreadable while providing a smooth and meting mouthfeel.

Moreover, studies on couverture chocolates (rich in cocoa butter) confirmed that higher fat content from cocoa butter contributes to superior texture and consumer perception of richness (de Sousa Dias et al., 2023). Thus, even modest increases in dark chocolate led to noticeable improvements in texture, reinforcing the role of cocoa butter as a key contributor to sensory quality.

3.3.4 Aroma

The aroma of the spread was notably improved by incorporating dark chocolate. Formulations F2 (10% dark chocolate), (6.23 ± 1.83) and F3 (15% dark chocolate), (6.43 ± 1.95) received notably higher scores compared to the control (5.22 ± 2.13) and F1 (5.68 ± 1.78) formulations. The unique aroma of cocoa, typical of dark chocolate, enhanced the complexity and richness of the overall sensory experience.

The enhanced aromatic profile of chocolate-enriched formulations is primarily driven by the development of key volatile compounds during roasting, most notably pyrazines, which contribute to the characteristic of 'roasted' and 'earthy' notes that define cocoa's olfactory appeal (Frauendorfer & Schieberle, 2006). Furthermore, the interplay between these volatiles and the underlying bitter-sweet complexity of the cocoa solids provides a sensory depth that heightens consumer allure, establishing aroma as a critical determinant of product acceptance (Afoakwa et al., 2008).

3.3.5 Overall taste

The addition of dark chocolate had a considerable impact on the overall taste of the spread. Formulations F3 (7.25 ± 1.28) and F2 (7.17 ± 1.32) received significantly higher scores compared to the control (6.67 ± 1.73) and formulation F1 (6.32 ± 1.75). The blend of sweet and bitter notes from the dark chocolate, paired with the subtle sweetness of the pumpkin and allulose, resulted in a balanced and enjoyable taste experience. The widespread attraction of chocolate in improving flavour has been thoroughly reported, with research by Simoes et al. (2018) highlighting its capability to cover up unwanted tastes and to offer a feeling of luxury.

Table 4: Sensory evaluation test of pumpkin fruit spread incorporated with dark chocolate

Attributes	Control	F1	F2	F3
Appearance	6.40 ± 1.84^a	6.52 ± 1.63^a	7.02 ± 1.45^b	7.06 ± 1.48^b
Colour	6.67 ± 1.73^a	6.32 ± 1.75^a	7.17 ± 1.32^b	7.25 ± 1.28^b
Texture	6.53 ± 1.58^a	6.35 ± 1.49^a	7.03 ± 1.39^b	6.75 ± 1.27^b
Aroma	5.22 ± 2.13^a	5.68 ± 1.78^a	6.23 ± 1.83^b	6.43 ± 1.95^b
Overall Taste	6.67 ± 1.73^a	6.32 ± 1.75^a	7.17 ± 1.32^b	7.25 ± 1.28^b

The presented results indicate a means value $\pm$ standard deviation. Values with different superscript letter in a row indicate statistically significant within the group at level $p < 0.05$.

Notes: Control (100% pumpkin)

F1 (inclusion of 5% dark chocolate)

F2 (inclusion of 10% dark chocolate)

F3 (inclusion of 15% dark chocolate)

4. CONCLUSION

This study demonstrated the potential of incorporating dark chocolate into pumpkin spread to enhance both nutritional and sensory properties. The 10% dark chocolate formulation (F2) achieved the best balance in terms of appearance, texture, aroma, and overall flavour. Proximate analysis revealed significant increases in protein and fat content with higher chocolate inclusion, supporting its role as a functional ingredient. The product demonstrated improved sensory quality and moderate nutrient compositional enhancement. These findings highlight dark chocolate's promise in developing healthier, value-added fruit spreads which moderately increased the nutritional content for health benefits. Further research is recommended to determine the optimal inclusion level for balancing nutrition, taste, and cost. Future work should also explore the addition of other functional ingredients and the potential use of this spread in

various value-added products like dips, fillings, or baked goods.

ACKNOWLEDGEMENT

The author(s) would like to acknowledge the financial support from Universiti Sains Islam Malaysia for the research, authorship, and/or publication of this article through the Innovation Development Grant Scheme (PPI/GPI/USIM/FST/16223) and Biduni Mizaniyyah Grant Scheme (PPPI/BM/FST/USIM/15223) and to Faculty of Science and Technology for the laboratories equipment provided. Special thanks are also extended to the Faculty of Agro-industrial and Biosystems Technology, Universitas Brawijaya for their technical support and insightful feedback throughout the Visiting Lecturer Program Batch 4, Year 2025.

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