

Physicochemical properties and sensory evaluation of sugar-free pumpkin spread formulated with allulose, monk fruit and stevia

Norshazila Shahidan¹, Nursyazwani Azizi², Wan Mohd Fadli Wan Mokhtar^{3*}, Zarinah Zakaria³, Nurul Zaizuliana Rois Anwar³, Noor Yuslida Hazahari⁴ and Nasrul Fikry Che Pa⁵

¹Faculty of Science and Technology, Universiti Sains Islam Malaysia, 71800, Bandar Baru Nilai, Negeri Sembilan, Malaysia

²Haus Berhad, 2A, 2nd Floor, Jalan Karas, Kempas Lama, 81300 Johor, Malaysia

³Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, 22200, Besut, Terengganu, Malaysia

⁴International Institute for Halal Research and Training (INHART), International Islamic University Malaysia (IIUM), Level 3, KICT Building, Jalan Gombak, 53100, Kuala Lumpur, Malaysia

⁵Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM) Hab Pendidikan Tinggi Pagoh, KM 1, Jalan Panchor, 84600 Panchor, Johor, Malaysia

ARTICLE HISTORY

Received : 3 July 2025

Accepted : 1 October 2025

Online : 31 March 2026

KEYWORDS

fruit spread,
physicochemical analysis,
pumpkin,
sensory evaluation,
sugar-free

✉ * CORRESPONDING AUTHOR

Wan Mohd Fadli Wan Mokhtar
Faculty of Bioresources and Food
Industry, Universiti Sultan Zainal
Abidin, Besut Campus, 22200, Besut,
Terengganu, Malaysia
Email: wfadli@unisza.edu.my

ABSTRACT

Pumpkin (*Cucurbita moschata*), a member of the gourd family Cucurbitaceae, is typically characterised by a hard orange rind with distinctive grooves. Pumpkin is a nutrient-dense fruit that offers numerous health benefits. However, studies on sugar-free pumpkin-based products remain limited in Malaysia. Therefore, this study aimed to determine the physicochemical properties and sensory evaluation of sugar-free pumpkin spreads prepared with different sweeteners. Four formulations were developed, i.e., a control with sugar (PSc), a sugar-free version using allulose (PSa), monk fruit (PSm), and stevia (PSs). Proximate analysis, total soluble solids, pH, texture, and sensory analysis were conducted on all formulations. Results showed that PSa, PSm, and PSs contain moisture of 72.28%, 72.66% and 73.87%, respectively, which were significantly ($p \leq 0.05$) higher than PSc (53.32%). For ash content, the highest value was recorded in PSs (6.53%), which also contained the highest protein (6.57%) and fat content (4.76%). Meanwhile, the highest fibre content was found in the PSm formulation (5.92%). However, the pH value for all samples showed no significant difference ($p > 0.05$), ranging from 6.41 to 6.43. While the total soluble solids (TSS) showed a significant difference ($p \leq 0.05$), PSc recorded the highest TSS value (44.88 °Brix) compared to the other formulations. For sensory evaluation, the analysis found that the most preferred formulation was PSc, followed by PSa, PSm, and PSs. These findings demonstrated the potential of alternative sweeteners in developing sugar-free pumpkin spreads with acceptable physicochemical and sensory properties.

© 2026 UMK Publisher. All rights reserved.

1. INTRODUCTION

Obesity has become one of the most public health concerns in most countries. Obesity is closely linked to lifestyle factors, particularly the daily dietary habits of individuals. One of the main dietary risk factors linked to obesity is the unregulated and excessive consumption of sugar (Stanhope, 2016). Consuming excessive amounts of sugar not only increases calorie consumption but also leads to metabolic problems such as insulin resistance, diabetes, and cardiovascular diseases. As a result, lowering sugar levels through the development of healthier food substitutes has emerged as a global agenda in research and food product innovation.

A product is classified as sugar-free if it contains less than 0.5 grams of sugar per 100 g or 100 ml, as specified by

the Food and Drug Administration (FDA) (Prada et al., 2021). In this regard, fruit-based spreads are an attractive category for sugar reduction because they are commonly consumed, adaptable, and naturally contain fibre, carbohydrates, vitamins, and minerals. Therefore, reformulating spreads to reduce or eliminate added sugar may help reduce calorie intake without compromising vital nutrients.

Pumpkin is particularly well-suited for the formulation of sugar-free spreads. Pumpkin is a widely grown, inexpensive crop belonging to the Cucurbitaceae family and possesses high nutritional and functional properties (Arifin et al., 2019). Pumpkin is naturally low in calories but rich in dietary fibre, which supports digestive health by enhancing gastrointestinal mobility and reducing the risk of digestive disorders (Nargiza Rajabbayevna et al., 2021). Furthermore, pumpkin has

several benefits in terms of its nutritional properties as it contains health bioactive compounds, essential minerals (magnesium, potassium, calcium, iron, and zinc), and several vitamins (A, B1, B2, B9, and C) (Al-Anoos et al., 2015; Arifin et al., 2019; Hosen et al., 2021).

Therefore, replacing sugar with alternative sweeteners in pumpkin-based products presents a promising strategy for obesity prevention. Natural sweeteners, i.e., allulose, monk fruit, and stevia, are known as low-calorie alternatives and are gaining interest due to increasing health concerns, particularly obesity. In addition to being intensely sweet, non-nutritive, and extremely stable, some of these sweeteners have been reported to have potential health advantages, including antihyperglycemic, antidiarrheal, antihypertensive, anti-inflammatory, and antidiuretic qualities in addition to immunomodulatory activities (Clos et al., 2008; Goyal et al., 2010; Wölwer-Rieck et al., 2010; Edwards et al., 2016). These attributes have led to increasing consumer and industry interest in their application for food development.

Therefore, the emerging demand for healthier food products has encouraged the exploration of low-calorie pumpkin spreads. Such products can offer a nutritious and low-calorie option to traditional sugar-based pumpkin spreads. However, it is critical to evaluate their physicochemical properties and sensory acceptability of formulations before commercialisation, which constitutes the main objective of this study.

2. MATERIALS AND METHODS

2.1. Materials

All ingredients for pumpkin spread preparation, including sugar, salt, vanilla essence, allulose, stevia, and monk fruit sweeteners, were purchased from the local market in Terengganu, Malaysia. All sweeteners used were food grade. Meanwhile, the fresh pumpkins (*Cucurbita moschata*), locally known as *labu manis* in Malaysia were obtained from the farm at UniSZA Campus Besut, Terengganu, Malaysia after 75 days of cultivation.

2.2. Preparation of pumpkin puree

The fresh pumpkins were peeled, halved, and the seeds were removed. Then, the flesh was cut into small cubes (approximately 3 cm x 3 cm x 3 cm) and washed to remove any remaining seeds. About 1 kg of pumpkin cubes were steamed in a steamer with 2 L of water for 30 minutes. Then, the cubes were blended into a smooth puree using a food processor.

2.3. Formulated sample preparation

Four formulations of pumpkin spread were prepared

in this study. These formulations were pumpkin spread with sugar as a control spread (PSc), pumpkin spread with allulose sweetener (PSa), pumpkin spread with monk fruit sweetener (PSm), and pumpkin spread with stevia sweetener (PSs). The sweetener was the only variable among formulations. The formulations were prepared by mixing all the ingredients based on Table 1. The variations among formulations were in the amount of sweetener, which was determined based on a preliminary study. The resulting mixture was then cooked on an electric stove at 100°C for 15 minutes while continuously stirring to prevent the spread from burning. After cooking, the spread was allowed to cool to 80°C for five minutes. Finally, the pumpkin spread samples were stored in a clear glass jar and capped before conducting the analyses.

Table 1: Formulation of pumpkin spread using different sweeteners

Ingredient	Amount (g)			
	PSc	PSa	PSm	PSs
Pumpkin puree	100	100	100	100
Vanilla essence	2	2	2	2
Salt	1	1	1	1
Sugar	40	-	-	-
Allulose	-	27	-	-
Monk fruit	-	-	8	-
Stevia	-	-	-	5

*PSc – sucrose pumpkin spread; PSa – allulose pumpkin spread; PSm – monk fruit pumpkin spread; PSs – stevia pumpkin spread.

2.4. Physicochemical properties

2.4.1. Proximate chemical analysis

The moisture content of the pumpkin spread was analysed using oven drying (AOAC, 2005). The crucible was weighed (W_1) once it met the room temperature ($28 \pm 2^\circ\text{C}$). Five grams of the sample were added to the crucible (W_2). The crucible with the sample was dried in the convection oven (Mettler UF30, Germany) at 105°C overnight. After that, the crucible was removed from the oven and cooled in the desiccator. The crucible was weighed after reaching the room temperature, $28 \pm 2^\circ\text{C}$ (W_3). The percentage of the moisture content on a wet basis is expressed below.

$$\% \text{Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Ash content of pumpkin spread was determined by a metal furnace (Carbolite CWF 1100, United Kingdom) according to AOAC (2005). The dry crucible was heated for 4 hours inside the oven at 105°C. The crucible was put into a desiccator for 30 minutes (W_1). Five grams of the sample were weighed into the dry crucible and were heated over the Bunsen burner until they ceased to smoke (W_2). The sample was placed into a muffle furnace at a temperature of 550°C overnight. The sample was removed from the muffle furnace

and allowed to cool in the desiccator before weighing. After they were cooled at room temperature, the sample was weighed (W_3), and the ash content was calculated based on the following equation.

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2} \times 100$$

The protein content in sugar-free pumpkin spread was determined by using the AOAC (2005) method, which is the Kjeldahl method. A volume of 10 ml H_2SO_4 added to three grams of the sample was digested with a Kjeldahl digester for 1 hour. After digestion, the distillation was conducted with 40% concentrated sodium hydroxide solution (Gerhardt VAPODEST 450, Germany). The conversion factor of 6.25 was used to calculate the protein content from the nitrogen content. Meanwhile, fat content was determined using the Soxhlet extraction method (Gerhardt SOX416, Germany). Three grams of the sample were extracted with 150 mL of petroleum ether for 4 hours. The extracted fat in the cup was then placed in an oven at 105 °C for 1 hour and cooled and weighed. The crude fibre analysis method gives an estimate of indigestible fibre in food, which is determined by sequential extraction of the sample with sulphuric acid, H_2SO_4 , and sodium hydroxide, NaOH. The analysis was conducted based on the Gerhardt Fibretherm Automated Fibre Analysis System (FT12, Germany) according to AOAC (2005).

Meanwhile, the total carbohydrate and total calorie content were calculated according to the following equation.

$$\text{Carbohydrate (\%)} = 100 - (\% P + \% F + \% A + \% M)$$

$$\text{Total calories} \left(\frac{\text{kcal}}{100 \text{ g}} \right) = 4(C + P) + 9(F)$$

Where P = protein content; F = fat content; A = ash content; M = moisture content and C = carbohydrate content.

2.4.2 Total soluble solid (TSS)

The dissolved sugar content of an aqueous solution is commonly determined using total soluble solids (TSS). The TSS, sometimes referred to as degrees Brix (°Brix). Brix represents the strength of a solution as a percentage by mass, with one degree Brix equalling one gram of sucrose in 100 grams of solution. The determination of soluble solid content in the pumpkin spread sample using a hand-held digital refractometer (Atago, 2383 MASTER-20M, Tokyo, Japan).

2.4.3 pH analysis

For pH analysis, a pH meter (Hanna Instruments pH211, Italy) was used to measure the pH of pumpkin fruit spread samples. A pH meter is an electronic instrument that contains a special bulb that is sensitive to hydrogen ions that are present in the solution. The pH meter was calibrated with a buffer solution to ensure accurate results. The 2 g sample was mixed with 4 ml of distilled water before the pH was measured.

2.4.4 Texture profile analysis

The texture profile analysis was conducted using a Texture Analyzer (TA-XT Plus, Stable Microsystems, Surrey, UK). Texture profile analyses were performed in compression mode using a cylindrical probe, with the pre-test speed at 1.00 mm/sec, test-speed at 3.00 mm/sec, post-test speed at 10.00 mm/sec, 5 g of trigger force, and distance at 23.0 mm. 20 g of the sample was placed in a container, and the sample was placed under the probe-carrying at the centre.

2.5. Sensory evaluation

The sensory evaluation test was conducted in separate rooms at Universiti Sultan Zainal Abidin Sensory Laboratory in Besut, Terengganu, Malaysia. Forty consumer panellists participated in this test to determine their preference among the four formulations of sugar-free pumpkin spread. Informed consent was obtained from all participants, and the study was approved by the Universiti Sultan Zainal Abidin Human Research Ethics Committee (UHREC) with reference number UniSZA/UHREC/2025/821. The score was based on a seven-point hedonic scale ranging from scale (1= dislike very much) to scale (7 = like very much). Each sample was given a unique number, and they were all prepared in identical containers and coded with three-digit random numbers. Each panellist was asked to evaluate attributes of colour, mouthfeel/texture, sweetness, flavour/aroma, and overall acceptability (1 = extremely dislike, 2 = very much dislike, 3 = moderately dislike, 4 = neither like nor dislike, 5 = moderately like, 6 = very much like, and 7 = extremely like). If the average scores exceeded 4, palatability was deemed satisfactory (neither like nor disliked).

2.6. Statistical analysis

The data obtained from the tests were analysed statistically in triplicate. All results were recorded as mean values \pm standard deviation. Analysis of variance (ANOVA) was performed using the Post Hoc Tukey Test and analysed with Microsoft Excel and SPSS software Version 22.0 at a $p \leq 0.05$ level of significance.

3. RESULTS AND DISCUSSION

3.1. Proximate composition of pumpkin spread

Proximate analysis is commonly used to measure or determine the basic composition of a food sample by measuring its moisture, crude protein, total fat, total carbohydrate, and crude fibre. Table 2 shows the proximate composition of each pumpkin spread sample. In general, a significant difference ($p \leq 0.05$) was identified between PSc and other samples in terms of moisture, ash, protein, crude fibre, and total carbohydrate contents. However, no significant difference ($p > 0.05$) was observed in fat content among the samples.

Moisture content represents the amount of water and volatile substances during drying treatment. PSc formulation had the lowest moisture content (53.32%) compared to PSa (72.28%), PSm (72.66%), and PSs (73.87%). This result indicates that the sugar used in the control sample is likely the main factor contributing to its lowest moisture content. At high concentrations of sugar, it can promote water migrations due to osmosis pressure and evaporation during the cooking process, resulting in a lower final moisture content in the final product (Sutwal et al., 2019; Lin et al., 2020).

Ash content is critical for determining the total or specific mineral content of foods (Harris & Marshall, 2017). Based on findings, PSs showed the highest ash content (6.53%), while PSc had the lowest (2.74%). The main reason can be attributed to the dilution effect of sugar, which is primarily composed of carbohydrates with contain minimal mineral contents, thus reducing the overall ash content in the final product. Moreover, stevia and monk fruit stevia itself contain trace minerals such as potassium, calcium, and magnesium, which may contribute to the overall ash content, unlike sugar, which is nearly mineral-free. This finding aligned with previous studies reporting that stevia and monk fruit contain significant mineral contents, particularly potassium, calcium, and magnesium, which could contribute to the overall ash content of pumpkin spread (Lemus-Mondaca et al., 2016; Khiraoui et al., 2017; Pandey & Chauhan, 2019).

Table 2: Proximate composition of sugar-free pumpkin spread samples

Composition	Formulations			
	PSc	PSa	PSm	PSs
Moisture (%)	53.32±0.05 ^c	72.28±0.28 ^b	72.66±0.36 ^b	73.87±0.18 ^a
Ash (%)	2.74±0.04 ^c	5.50±0.23 ^b	6.11±0.02 ^{ab}	6.53±0.58 ^a
Protein (%)	3.06±0.09 ^b	5.97±0.12 ^a	6.48±0.03 ^a	6.57±0.59 ^a
Fats (%)	4.65±0.31 ^a	4.62±0.17 ^a	4.66±0.23 ^a	4.76±0.18 ^a
Crude Fibre (%)	3.13±0.26 ^b	5.28±0.05 ^{ab}	5.92±0.32 ^a	5.80±0.11 ^a
Total Carbohydrate (%)	36.24±0.36 ^a	11.63±0.18 ^b	10.09±0.64 ^c	8.27±0.89 ^d
Total Calories (kcal/100 g)	199.03 ^a	111.97 ^b	108.25 ^b	102.18 ^c

The means ± standard deviation are used to present all data. There is a significant difference ($p \leq 0.05$) between the mean and standard deviation of the different letters in the same row.

Regarding carbohydrate content, PSc significantly ($p < 0.05$) had the highest value (36.24%), followed by PSa (11.63%), PSm (10.09%), and PSs (8.27%), as shown in Table 2. Similarly, the total calorie content was highest in PSc (199.03 kcal/100g), followed by PSa (111.9 kcal/100 g), PSm (108.25 kcal/100 g), and PSs (102.18 kcal/100g). Meanwhile, the protein content in the spread mainly comes from its primary ingredients, including pumpkin and monk fruit, and stevia (Lalnunthari et al., 2020). Monk fruit is rich with amino acids that contain sulphur, such as methionine, S-methylmethionine, cystine, and cysteine, while stevia also contains amino acids (Khattab et al., 2015; Ban et al., 2020; Latarissa et al., 2020; Siddhi et al., 2022). However, sucrose used in the control pumpkin spread sample contributed the least to protein content, as sucrose is known primarily as a carbohydrate component. In contrast, allulose, a natural sweetener derived from plants, mainly corn, exhibited a remarkable protein content, likely due to trace protein residues from its production process. This explains why the protein content in PSa, PSm, and PSs showed significant differences ($p < 0.05$) compared to the control (PSc) sample. In this study, the fat content in most samples was around 4.6%, equivalent to 4.6 g/100g, and the fat content was mainly derived from pumpkin puree. Pumpkin fat comprises both saturated and unsaturated fatty acids, and the fatty acid composition of pumpkin flesh is influenced by factors such as locality, maturity stage, and processing conditions (Amin et al., 2019).

Regarding fibre content, the pumpkin spread with monk fruit recorded the highest values, followed by stevia pumpkin spread, allulose pumpkin spread, and control pumpkin spread. Based on the previous study, whole monk fruit contained 2.88% to 5.65% polysaccharides, consisting of starch and dietary fibre (Pandey & Chauhan, 2019). Although the monk fruit sweetener may not have as much fibre as the whole fruit, a small amount of fibre may still be present in the sweetener. This could partly explain why the pumpkin spread with monk fruit had a comparatively higher fibre content than the sugar-based spread. Meanwhile, according to Yu et al. (2020), the fibre content in stevia is approximately 22%, while Khiraoui et al. (2017) reported ranged between 17% and 19%, depending on the geographical areas. It is well known that sucrose, used in the PSc sample, contributes no fibre as it is primarily composed of glucose and fructose. Meanwhile, according to USDA (2018), pumpkin flesh contains about 6.5% carbohydrates per 100 g, which naturally contributes to the total carbohydrate content of all pumpkin spread samples, as shown in Table 2. The PSc sample had the highest carbohydrate level due to sucrose is essentially a pure carbohydrate and was added at a higher concentration in preparation for the pumpkin spread. The same trend was also

observed for total calories, where PSc provided the highest calorie content among the samples. This is logically attributed to the high sugar content in the pumpkin spread, which serves as the primary contributor to energy value. Based on this research, the total calorie content of pumpkin fruit spread can be reduced by up to 49% with stevia, 46% with monk fruit sweetener, and 44% with allulose sweetener. These reductions demonstrate that the potential of pumpkin spreads made with alternative sweeteners could be marketed as low-calorie products.

3.2. Physicochemical properties of pumpkin spread

The total soluble solids content in Table 3 for PSc, PSa, PSm, and PSs formulations showed a significant difference ($p < 0.05$) among all the sugar-free pumpkin spread samples. The highest value of total soluble solids was recorded in PSc (44.88 °Brix), followed by PSa (27.86 °Brix), PSm (24.85 °Brix), and PSs (22.71 °Brix). The pumpkin spread sample with sucrose had the highest TSS, which can be attributed to the total sugars, including fructose, sucrose, and glucose.

These results aligned with the results of previous researchers, who observed a decrease in the total soluble solids of green tea agar jellies when using sweeteners such as monk fruit and stevia (Akesowan & Choonhahirun, 2021). Although no sugar was added, the sugar-free pumpkin spread made with sweeteners still contains total soluble solids (as shown in Table 3) due to the presence of naturally occurring components in pumpkin. Pumpkin naturally contains sugars such as glucose, fructose, and sucrose, which contribute to the TSS value. Meanwhile, statistical analysis revealed no significant difference ($p > 0.05$) in the pH values among all samples. The pH values ranged from 6.40 to 6.45, falling within the slightly acidic to neutral category, which is typical for many fruits and vegetables (Cohen et al., 2014).

Table 3: Total soluble solids and pH values of sugar-free pumpkin spread samples

	Sample			
	PSc	PSa	PSm	PSs
Total Soluble Solid (°Brix)	44.88±0.52 ^a	27.86±0.81 ^b	24.85±0.62 ^c	22.71±0.58 ^d
pH	6.43±0.00 ^a	6.41±0.01 ^b	6.43±0.01 ^a	6.43±0.01 ^{ab}

The means ± standard deviation are used to present all data.

There is a significant difference ($p < 0.05$) between the mean and standard deviation of the different letters in the same row.

Figures 1 and 2 show significant differences in firmness and work of shear values among the samples, with PSc exhibiting the lowest values. The firmness determines the spreadability of the pumpkin spread, referring to how easily the product can be spread. Spreadability is a desirable feature of products like margarine, butter, jam, and chocolate

spreads. It relates to how uniformly the product can be distributed over a surface and depends on the hardness of the spread and the work of shear required. In this study, the texture of pumpkin spread was influenced by the type of sweetener, where formulation containing stevia showed the highest firmness, while the sucrose-based spread showed the lowest firmness value. This trend can be explained by the functional role of sucrose in lowering gel strength and increasing spread ability. Meanwhile, using high-intensity sweeteners reduces the dilution of the natural pectin of pumpkin, resulting in a firmer texture.

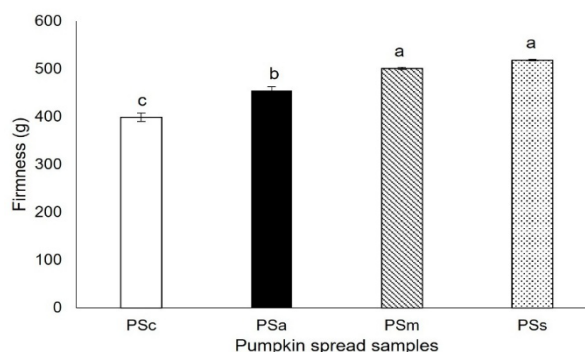


Figure 1: Firmness value of pumpkin of sugar-free pumpkin spread samples

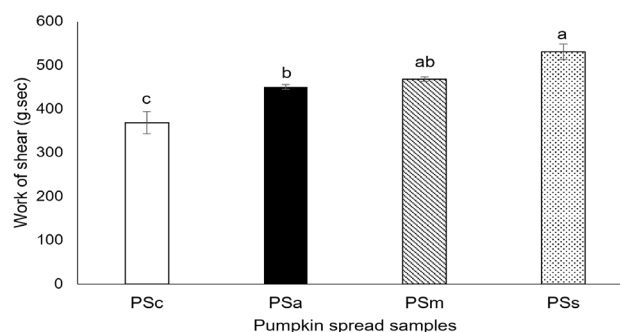


Figure 2: Work of shear value of pumpkin of sugar-free pumpkin spread samples

Work of shear is defined as the force required to cut through a sample in bulk, measured as an average across multiple pieces or weights. Smaller values of the work of shear indicate better spread ability of the sample (Dubost et al., 2003). The texture properties of pumpkin spread are generally smooth and creamy, making it easy to spread on toast, crackers, or pancakes. However, the texture of the spread might be influenced by the amount of sugar or other ingredients, as pumpkin itself contributes unique flavours and textures, including natural pectin and acid that can act as gelling agents (Ramachandran et al., 2022). Similar findings from previous studies have shown that substituting sugar with alternative sweeteners can significantly alter texture. For instance, jam made with stevia exhibited significantly higher hardness and reduced spreadability than the sucrose controls. This characteristic was due to decreased dilution of the fruit

matrix and changes in water-binding capacity (Nourmohammadi et al., 2021). Likewise, cantaloupe jams prepared with xylitol as a partial replacement for sucrose showed increased firmness and had different viscoelastic properties, which means that sucrose reduction leads to firmer gels (Naknaen & Itthisoponkul, 2015). Similarly, purple yard-long bean jams made with sucralose and xylitol demonstrated a higher hardness value than jams made with sucrose (Thaweeseang et al., 2022).

Pumpkin spread is typically formulated to be easily spreadable, with a smooth and creamy texture that provides a pleasant mouthfeel. Previous findings are consistent with the present study, where pumpkin spreads sweetened with stevia, monk fruit, and allulose exhibited firmer textures than the sucrose-based control. Therefore, the comparative results across various fruit-based spreads highlight the critical role of sucrose in modulating texture and spread ability. Its replacement with alternative sweeteners generally leads to firmer products with reduced ease of spreading.

3.3. Sensory evaluation

The satisfaction and acceptance of participants regarding the four formulations of pumpkin spread were evaluated using a sensory evaluation analysis. In general, Table 4 shows no significant differences ($p > 0.05$) in the aroma, flavour, and sweetness scores among the four formulations, indicating that alternative sweeteners did not significantly alter these attributes. However, the results found that PSc obtained significantly higher satisfaction scores, followed by PSa, in texture, colour, and overall acceptability. In contrast, PSm and PSs recorded lower scores, particularly in texture and overall acceptability, as shown in Table 4.

Table 4: Sensory evaluation of sugar-free pumpkin spread samples

Attributes	Sample			
	PSc	PSa	PSm	PSs
Aroma	5.60±1.10 ^a	5.08±1.51 ^a	5.00±1.26 ^a	5.08±1.53 ^a
Texture	6.30±1.02 ^a	5.28±1.55 ^b	3.63±1.75 ^c	3.23±1.56 ^c
Colour	6.10±1.06 ^a	5.50±1.32 ^{ab}	5.00±1.59 ^b	5.00±1.45 ^b
Flavour	5.70±1.56 ^a	5.30±1.52 ^a	4.83±1.58 ^a	4.95±1.38 ^a
Sweetness	5.05±1.80 ^a	5.08±1.46 ^a	4.68±1.40 ^a	4.75±1.68 ^a
Overall Acceptability	5.65±1.25 ^a	5.23±1.54 ^{ab}	4.50±1.40 ^{bc}	4.30±1.44 ^c

The means ± standard deviation are used to present all data. There is a significant difference ($p \leq 0.05$) between the mean and standard deviation of the different letters in the same row.

The findings also revealed that the scores of the aroma attribute for pumpkin fruit spread ranged from 5.00 (PSm) to 5.60 (PSc), revealing that the respondents moderately liked the aroma of all samples, as shown in Table 4. The samples showed no significant differences ($p > 0.05$) in aroma attributed, indicating that the sweeteners used did not

markedly affect the aroma perfection. This result is in line with previous findings that the fruit matrix itself has a greater impact on aroma in fruit-based spreads (Thaweeseang et al., 2022).

Table 4 shows that PSc received the highest score of texture attribute, followed by PSa, while PSm and PSs were rated less favourably. This preference is consistent with texture results (Figure 1), which showed that PSc exhibited the lowest firmness and produced a smooth and creamy mouthfeel. Meanwhile, formulations with stevia and monk fruit resulted in firmer gels that panellists found less palatable. Similar findings also reported that jams prepared with alternative sweeteners increased firmness and reduced spreadability. (Naknaen & Itthisoponkul, 2015; Thaweeseang et al., 2022).

The score for colour preference ranged from 5.00 to 6.10, with a remarkable difference between the PSc sample and other samples. However, the colour score indicated that the respondents moderately liked all the samples. The slight reduction in colour preference in sugar-free spreads may be due to distinct browning and caramelization characteristics of sweeteners compared to sucrose. There is no significant difference ($p > 0.05$) recorded in flavour and sweetness attributes for all samples, demonstrating that sugar substitutes were able to replicate the sweetness intensity of sucrose accurately. This is consistent with Haroon et al. (2024), who reported that jams made with stevia and sorbitol maintained comparable sweetness taste to sucrose formulations.

In terms of overall acceptability, PSc was recorded as the most preferable sample, followed by PSa, PSm, and PSs. Although sucrose is preferred for consumer satisfaction, the lack of notable differences in aroma, colour, flavour, and sweetness indicates that sugar-free spreads, particularly PSa, can still be considered acceptable by consumers. Regarding health benefits, sugar-free pumpkin spread would offer a better choice, especially for those in weight management loss and those seeking a diabetic friendly fruit spread.

4. CONCLUSION

The study reveals that the use of alternative sweeteners in pumpkin spreads significantly affected their proximate chemical analysis. Pumpkin spreads with allulose, stevia, and monk fruit showed an increased in moisture, ash, protein, and fibre contents compared to the sucrose-based pumpkin spread. Despite these variations, sugar-free pumpkin spread offers potential health benefits, especially for weight management and as diabetic-friendly food products, due to its low-calorie content, which ranged from 44% to 49%. In terms of product acceptability, there were no significant differences observed between the control sample and sugar-free pumpkin spread with allulose (PSa) flavor and sweetness attributes.

However, PSa exhibited lower acceptability in texture properties, indicating the need for further studies to improve its texture quality before it can be marketed as a commercially viable spread.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Universiti Sultan Zainal Abidin (UniSZA) for funding this research under the University Research Grant 2.0 (UniSZA/2022/DPU2.0/09) and for providing the necessary facilities to conduct the experiments.

REFERENCES

- Akesowan, A., & Choonhahirun, A. (2021). The use of stevia and monk fruit sweeteners for sugar replacement in green tea agar jellies. *Food SciTech Journal.*, 3(2), 93–100. <https://doi.org/10.33512/fsj.v3i2.12404>
- Al-Anoos, I., El-dengawy, R., & Hasanin, H. (2015). Studies on chemical composition of some Egyptian and Chinese pumpkin (*Cucurbita maxima*) seed varieties. *Journal of Plant Science & Research.*, 2(2), 1–4.
- Amin, M. Z., Islam, T., Uddin, M. R., Uddin, M. J., Rahman, M. M., & Satter, M. A. (2019). Comparative study on nutrient contents in the different parts of indigenous and hybrid varieties of pumpkin (*Cucurbita maxima* Linn.). *Heliyon.*, 5(9), 1–5. <https://doi.org/10.1016/j.heliyon.2019.e02462>
- AOAC. (2005). *Determination of moisture, ash, protein and at. Official method of analysis of the association of analytical chemists*. 18th Edition, AOAC, Washington DC. In AOAC International (Vol. 18).
- Arifin, N., Siti Nur Izyan, M. A., & Huda-Faujan, N. (2019). Physical properties and consumer acceptability of basic muffin made from pumpkin puree as butter replacer. *Food Research.*, 3(6), 1–6. [https://doi.org/10.26656/fr.2017.3\(6\).090](https://doi.org/10.26656/fr.2017.3(6).090)
- Ban, Q., Liu, Z., Yu, C., Sun, X., Jiang, Y., Cheng, J., & Guo, M. (2020). Physicochemical, rheological, microstructural, and antioxidant properties of yogurt using monk fruit extract as a sweetener. *Journal of Dairy Science.*, 103(11), 10006–10014. <https://doi.org/10.3168/jds.2020-18703>
- Clos, J. F., DuBois, G. E., & Prakash, I. (2008). Photostability of rebaudioside A and stevioside in beverages. *Journal of Agricultural and Food Chemistry.*, 56(18), 8507–8513. <https://doi.org/10.1021/jf801343e>
- Cohen, S., Itkin, M., Yeselson, Y., Tzuri, G., Portnoy, V., Harel-Baja, R., Lev, S., Saà Ar, U., Davidovitz-Rikanati, R., Baranes, N., Bar, E., Wolf, D., Petreikov, M., Shen, S., Ben-Dor, S., Rogachev, I., Aharoni, A., Ast, T., Schuldiner, M., Schaffer, A. A. (2014). The pH gene determines fruit acidity and contributes to the evolution of sweet melons. *Nature Communications.*, 5, 1–9. <https://doi.org/10.1038/ncomms5026>
- Dubost, N. J., Shewfelt, R. L., & Eitenmiller, R. R. (2003). Consumer acceptability, sensory and instrumental analysis of peanut soy spreads. *Journal of Food Quality.*, 26(1), 27–42. <https://doi.org/10.1111/j.1745-4557.2003.tb00224.x>
- Edwards, C. H., Rossi, M., Corpe, C. P., Butterworth, P. J., & Ellis, P. R. (2016). The role of sugars and sweeteners in food, diet and health: alternatives for the future. *Trends in Food Science and Technology.*, 56, 158–166. <https://doi.org/10.1016/j.tifs.2016.07.008>
- Goyal, S. K., Samsher, & Goyal, R. K. (2010). Stevia (*Stevia rebaudiana*) a bio-sweetener: a review. *International Journal of Food Sciences and Nutrition.*, 61(1), 1–10. <https://doi.org/10.3109/09637480903193049>
- Haron, M., Khan, I., Ejaz, A., Afzaal, M., Saeed, F., Farooq, M. U., Ehsan, M., Ahmed, F., Akram, N., & Hailu, G. G. (2024). Preparation and quality evaluation of mixed fruit jam made from natural and artificial sweetener. *eFood.*, 5(6), 1–11. <https://doi.org/10.1002/efd2.70022>
- Harris, G.K., Marshall, M.R. (2017). *Food Analysis*. 5th. Ed. Springer, 287-297.
- Hosen, M., Rafii, M. Y., Mazlan, N., Jusoh, M., Oladosu, Y., Chowdhury, M. F. N., Muhammad, I., & Khan, M. M. H. (2021). Review pumpkin (*Cucurbita* spp.): a crop to mitigate food and nutritional challenges. *Horticulturae.*, 7(10), 1–25. <https://doi.org/10.3390/horticulturae7100352>
- Khattab, S. N., Massoud, M. I., Jad, Y. E. S., Bekhit, A. A., & El-Faham, A. (2015). Production and physicochemical assessment of new stevia amino acid sweeteners from the natural stevioside. *Food Chemistry.*, 173, 979–985. <https://doi.org/10.1016/j.foodchem.2014.10.093>
- Khiraoui, A., Bakha, M., Amchra, F., Ourouadi, S., Boulli, A., Al-Faiz, C., & Hasib, A. (2017). Nutritional and biochemical properties of natural sweeteners of six cultivars of *Stevia rebaudiana* Bertoni leaves grown in Morocco. *Journal of Materials and Environmental Science.*, 8(3), 1015–1022.
- Lalnunthari, C., Devi, L. M., & Badwaik, L. S. (2020). Extraction of protein and pectin from pumpkin industry by-products and their utilization for developing edible film. *Journal of Food Science and Technology.*, 57(5), 1807–1816. <https://doi.org/10.1007/s13197-019-04214-6>
- Latarissa, I. R., Barliana, M. I., & Lestari, K. (2020). A comprehensive review of *Stevia rebaudiana* Bertoni effects on human health and its mechanism. *Journal of Advanced Pharmacy Education & Research.*, 10(2), 91–95.
- Lemus-Mondaca, R., Ah-Hen, K., Vega-Gálvez, A., Honores, C., & Moraga, N. O. (2016). *Stevia rebaudiana* leaves: effect of drying process temperature on bioactive components, antioxidant capacity and natural sweeteners. *Plant Foods for Human Nutrition.*, 71(1), 49–56. <https://doi.org/10.1007/s11130-015-0524-3>
- Lin, C., Cui, H., Wang, X., Wang, H., Xia, S., Hayat, K., Hussain, S., Tahir, M. U., & Zhang, X. (2020). Regulating water binding capacity and improving porous carbohydrate matrix's humectant and moisture proof functions by mixture of sucrose ester and *Polygonatum sibiricum* polysaccharide. *International Journal of Biological Macromolecules.*, 147, 667–674. <https://doi.org/10.1016/j.ijbiomac.2020.01.101>
- Naknaen, P., & Itthisoopkul, T. (2015). Characteristics of Cantaloupe Jams as Affected by Substitution of Sucrose with Xylitol. *International Journal of Fruit Science.*, 15(4), 442–455. <https://doi.org/10.1080/15538362.2015.1031433>
- Nargiza Rajabbayevna, H., Karim Turayevich, D., Gulnoza Boymuratovna, B., & Hulkar Normurodovna, H. (2021). Importance of dietary fibers in health. *European Journal of Research Development and Sustainability.*, 2(4), 123–124. <https://www.scholarzest.com>
- Nourmohammadi, A., Ahmadi, E., & Heshmati, A. (2021). Optimization of physicochemical, textural, and rheological properties of sour cherry jam containing stevioside by using response surface methodology. *Food Science and Nutrition.*, 9(5), 2483–2496. <https://doi.org/10.1002/fsn3.2192>
- Pandey, A. K., & Chauhan, O. P. (2019). Monk fruit (*Siraitia grosvenorii*)-health aspects and food applications. *Pantnagar Journal of Research.*, 17(3), 191–198.
- Prada, M., Saraiva, M., Sério, A., Coelho, S., Godinho, C. A., & Garrido, M. V. (2021). The impact of sugar-related claims on perceived healthfulness, caloric value and expected taste of food products. *Food Quality and Preference.*, 94, 104331. <https://doi.org/10.1016/j.foodqual.2021.104331>
- Ramachandran, P., Dhiman, A. K., Attri, S., Vikram, A., Rai, S., & Sangeeta, S. (2022). Comparative study on physical characteristics and nutritional composition of pumpkin (*Cucurbita moschata*) at different stages of maturity. *Indian Journal of Traditional Knowledge.*, 21(4), 856–864. <https://doi.org/10.56042/ijtk.v21i4.32425>
- Siddhi, L. P., Vrushali, T. S., Sanika, B. H., Jyoti, G. S., Anuja, K. T., & Bangar, S. S. (2022). A review on: swingle fruit (monk fruit). *World Journal of Pharmaceutical Research.*, 11(16), 920–929. <https://doi.org/10.20959/wjpr202216-26375>
- Stanhope, K. L. (2016). Sugar consumption, metabolic disease and obesity: the state of the controversy. *Critical Reviews in Clinical Laboratory Sciences.*, 53(1), 52–67. <https://doi.org/10.3109/10408363.2015.1084990>
- Sutwal, R., Dhankhar, J., Kindu, P., & Mehla, R. (2019). Development of low-calorie jam by replacement of sugar with natural sweetener stevia. *International Journal of Current Research and Review.*, 11(4), 9–16. <https://doi.org/10.31782/IJCRR.2019.11402>
- Thaweeseang, N., Lueangprasert, K., & Saelim, K. (2022). Effects of alternative sweeteners on physical, chemical and sensory characteristics of purple yard long bean jam. *Recent Science and Technology.*, 14(1), 91–102.
- USDA. (2018). *FoodData Central*. *FoodData Central*. <https://fdc.nal.usda.gov/food-details/168448/nutrients>
- Wölwer-Rieck, U., Tomberg, W., & Wawrzun, A. (2010). Investigations on the stability of stevioside and rebaudioside A in soft drinks. *Journal of Agricultural and Food Chemistry.*, 58(23), 12216–12220. <https://doi.org/10.1021/jf102894v>
- Yu, M., Gao, T., Liu, Z., & Diao, X. (2020). Effects of dietary supplementation with high fiber (stevia residue) on the fecal flora of pregnant sows. *Animals.*, 10(12), 1–19. <https://doi.org/10.3390/ani10122247>