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Effect of Varying Oil Types on Physicochemical Properties and Sensory Evaluation of Pumpkin Seed Spread

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Abstract

In recent years, the popularity of plant-based spread, or butters has grown significantly due to increasing consumer demand for healthier food options. This study focused by utilizing pumpkin seed as one of the new alternative and healthy option for nut spread that derives form seeds. Pumpkin seeds are a great source of vitamins, minerals, unsaturated fats, and essential amino acids that are suitable to be one of the healthier options. This spread not only great option for those with nut allergies but also suitable for vegan and gluten free diets. The purpose of this study is to evaluate the physicochemical properties and sensory evaluation of pumpkin seed spreads that formulated with three different oils which were palm, corn and olive oil. The physicochemical properties were conducted to determine the moisture content, pH, total sugar content, colour measurement and firmness of the pumpkin seed spread. According to the result, the firmness of the pumpkin seed spread is the most critical factor influencing its Spreadability. The most favourable sample among the seven samples was sample 6, which contains 6% of palm and olive oil with value of firmness 22.26 N. The sample that consists of 6% of palm and olive oil was the easiest to spread compared to the others formulation. Besides, the sensory evaluation was conducted to analysed consumer preference based on Spreadability and overall acceptance. Sensory was carried in 9-point hedonic scale for rating the samples and t-test analysis was showed that consumer more preferred on sample 6. There were no significant differences in terms of appearance, colour and aroma where ($p>0.05$). In terms of Spreadability, flavour, texture and overall acceptance showed significance differences where ($p<0.005$). Nutritional value of pumpkin seed spread determined by using sample 6 that most preferable by the consumer with the energy value was 379 Kcal. Pumpkin seed spread with a content of 6% palm and olive oil gives the change in customer satisfaction and purchasing.

1. Introduction

A spread is a semi-solid food product that can be spread on bread or crackers. According to (Kaur & Maruf, 2018), Spreads produced from nutrient-dense seeds such as sesame, sunflower, and pumpkin seeds are also gaining popularity as functional spreads. Nuts and seeds have significant levels of polyphenolic flavonoids, which are antioxidants like lutein and carotenes and are thought to give a variety of health advantages. Seed butter is a valuable source of protein and other essential nutrients. In recent years, nut and seed butters and

spreads have gained popularity among consumers due to high in protein, fiber, vital fatty acids, and other nutrients. These spreads are a better option for a balanced diet and lifestyle than dairy butter products, which are high in cholesterol [1]. Pumpkin seeds are often considered "Superseeds" and are utilized as ingredients in bakeries or enjoyed roasted and salted in many countries [2]. The lack of a wide variety of pumpkin seed products on the Malaysian market, including spreads, snacks, and roasted pumpkin seeds, can be attributed to the limited product diversity.

This study focused on used palm, corn, and olive oil because they are easy to find and reasonably priced. The Malaysian Palm Oil Council (MPOC) state that, Palm oil is found in almost 50% of food products in the supermarket requiring a fat component. From chocolates to biscuits and peanut butter to ice-cream, palm oil in its various forms and derivatives are a common ingredient in these food products. Besides, corn oil is extracted from the germ of maize which contains high polyunsaturated fatty acid. Olive oil is an oil obtained from the fruit of the Olea europaea (olive tree), a traditional tree crop from the Mediterranean region, which fruits are wholly pressed to produce oil [3]. Olive oil contains polyphenols, natural compounds with multiple phenolic groups. The polyphenols in olive oil range from 50 to 1000 mg/kg [4]. Olive oil is also a monounsaturated fat that brings health benefits to its consumers. In this study, three different types of oil (palm oil, olive oil, and corn oil) were added to pumpkin seed spreads to assess their impact on Spreadability of spread. Oil is an essential ingredient in butter and spreadable foods since it influences the texture and Spreadability of these foods in addition to providing nutrients.

United States Department of Agriculture (USDA) regulations, nut butter needs to have a minimum of 90% nuts, while nut spread needs to have at least 40% nuts combined with nut oil. The chosen of palm, corn and olive oil is quite common in different spread products. According to [5], palm oil in chocolate spread is more spreadable due to its firmness. The Spreadability of the chocolate spread is reflected by its firmness. Palm oil and its fractions improve consistency, texture, and structure in margarines and shortenings without requiring hydrogenation. Excessive oil content may lead to a product that is excessively liquid rather than easily spreadable, with a propensity for oil separation [6]. Butter or spread products require oil as a crucial element that influences the texture and Spreadability of these products. This study was focused on developing pumpkin seed spread with different formulated oil types to influence its Spreadability. The physicochemical properties of pumpkin seed spread were analysed by its moisture, pH, colour, firmness and total sugar and sensory evaluation were conducted to determine the consumer preferences of the spreads.

2. Formulation of Pumpkin Seed Spread

Pumpkin seed, honey, palm oil, corn oil, olive oil, salt and carboxyl methylcellulose were used in this study. All of the ingredients are at Baked with Yen, a local bakery shop at Muar, Johor.

2.1 Formulation of Pumpkin Seed Spread

The seed spread is produced by using the formula shown in Table 1. This formulation comprises grams of Pumpkin seed, honey, palm oil, corn oil, olive oil, salt and carboxyl methylcellulose. The pumpkin seed were roasting in the oven for approximately 40 minutes (110˚c). The roasted pumpkin seeds will be combined with all the other ingredients in a food processor. The spread was blended for approximately 5-6 minutes until smooth consistency.

Table 1 The formulation of pumpkin seed spread (g)

Ingredients	F1	F2	F3	F4	F5	F6	F7
Pumpkin seed	100	100	100	100	100	100	100
Honey	10	10	10	10	10	10	10
Salt	2	2	2	2	2	2	2
CMC	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Palm oil	8	-	-	8	8	8	-
Corn oil	-	8	-	8	8	-	8
Olive oil	-	-	8	8	-	8	8

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2.2 Physicochemical Analysis of Pumpkin Seed Spread

Physicochemical analyses (pH, total soluble solids, colour, moisture content and firmness) are performed on each pumpkin seed spread utilizing different oils. Each sample formulation undergoes all analysis parameters in triplicate.

2.2.1 Moisture Content

The moisture content of spreads sample is evaluated by using a moisture analyser (A & D, MX-50, USA). A 1g pumpkin seed spread sample is weighed and spread on the tray and heated in the moisture analyser at 140°C for 15 minutes. The test was done triplicate, and the average outcome was calculated and published.

2.2.2 pH Analysis

The pH value of pumpkin seed spread is measured using a digital pH meter (Eutech, pH 700). The pH meter was calibrated before the analysis started. Next, the 1g of pumpkin seed spread was placed in the beaker. The pH electrode was dipped into the sample. The electrode of a pH meter analyses the voltage the solution creates, which is then translated to pH using the calibrated values. The hydrogen ion concentration is recorded by the pH meter, which produces a pH value that indicates the degree of acidity (pH less than 7), neutrality (pH 7), or alkalinity (pH greater than 7). The pH electrode was handled with extreme care by the guidance of pH meter manufacturer's instructions to properly maintain their accuracy. The pH meter is routinely calibrated to preserve precision and uniformity. The test was done triplicate, and the average outcome was calculated and published.

2.2.3 Total Soluble solid

A digital refractometer is used (Digital Refractometer RX-α Series) to determine total soluble solids content. The analysis involved placing samples onto a refractometer detector, stabilizing the temperature, and then measuring Brix, which reveals the amount of sugar (TSS) in the sample. The observation was made on the refractometer scale radar screen. The test was done triplicate, and the average outcome was calculated and published.

2.2.4 Colour

The colour of pumpkin seed spread was evaluated by using a Colour Spectrophotometer (Hunter Lab MiniScan EZ 4500, USA) with a 1.2 cm diameter aperture. Before the measurements, The MiniScan EZ Hunter Lab 4500 was calibrated before the test. Ten grams of the pumpkin seed spread were placed in the Hunter Lab instrument's glass container. The result obtained is expressed as CIE (L*, a*, b*) system, the parameters included the L* value (representing lightness/darkness), a* value (representing greenness), and the b* value (representing yellowness). The test was done triplicate, and the average outcome was calculated and published.

2.2.5 Texture Profile Analysis

The Texture measurements were carried out by using Texture analyser (TA. XTplusC Stable Micro System Ltd., Godalming, United Kingdom). A texture analyser calibrated a 5 kg load cell to assess textural properties such as hardness, firmness, and Spreadability. This analysis used a A cone-shaped acrylic probe (400) was used for the taking the reading hardness of spread. The spread sample was then placed on stage, and the probe head should be adjusted to contact the sample's surface. The highest force needed to compress the spread during a given time frame was recorded. The texture properties that were evaluated and observed was the firmness of the pumpkin seed spread. The data analysed for a better understanding of the textural characteristic that influences the Spreadability of the pumpkin seed spread. The test was done triplicate, and the average outcome was calculated and published.

2.3 Nutritional Composition of Pumpkin Seed Spread

2.3.1 Energy Content

The energy content analysis was carried out to produce pumpkin seed spread. The physiological energy values of the protein, fat, and carbohydrate contents were multiplied, and the resulting values were combined, for determining the energy content.

$$\text{Energy (kcal/100g)} = (4 \times \text{Carbohydrate})\ \text{g} + (4 \times \text{Protein})\ \text{g} + (9 \times \text{Fat})\ \text{g} \quad [1]$$

2.3.2 Carbohydrates

The carbohydrates percent in the pumpkin seed spread were determined by using the method by the Association of Official Analytical Chemists (AOAC)

$$\text{Carbohydrate} = 100 - (\%\text{Moisture} + \%\text{Fat} + \%\text{Protein} + \%\text{ Crude fiber} + \%\text{Ash}) \quad [2]$$

2.3.3 Protein

The protein content of the pumpkin seed spread for each formulations sample will be determined using a Kjeldahl apparatus following AOAC (2000) recommendations. 0.8g of pumpkin seed spread was digested in the Kjeldahl digestion system under a fume chamber. Sample has been weighed, transferred into digestion flask, and mixed with 5g Kjeldahl catalyst (90% K2SO4 and 10% CuSO4) and 200ml of concentrated H2SO4. Other flasks with 5g Kjeldahl catalyst (90% K2SO4 and 10% CuSO4) and 200ml of concentrated H2SO4 but without the sample was also made as blank solution. These flasks were put in an inclined position and heated until solution turns clear. Next, the solution has been cooled down and added with 60 ml distilled water. The flask with added water was connected to condenser and the tip of condenser soaked in standard acid and 5 drops of mix indicator in the receiver. The solution was heated until all the NH3 is distilled. The receiver has been removed and titrate with 0.2N HCl solution. The volume of HCl solution used was recorded and the total protein content of pumpkin seed spread was calculated by using formula below.

$$\text{Protein\%} = \frac{(A-B)\times N\times 1.4007\times 6.25}{W} \quad [3]$$

A= amount of 0.2N HC1 used in sample titration
B= amount of 0.2N HC1 used in blank titration
N= normality of HC1
W= weight of sample (g)
1.4007= atomic weight of nitrogen
6.25= protein-nitrogen conversion

2.3.4 Fat

The fat content of the pumpkin seed spread was determined by using the AOAC method. two grams of the material were weighed and put into Soxhlet thimbles. The extraction flask was weight before these thimbles should place onto it. Diethyl ether extraction required five hours to complete. Diethyl ether is eliminated by evaporation on an electric bath after the extraction is finished. After cooling for fifteen minutes and drying for thirty minutes at 60 °C in the oven, the remaining fat in the flask was weighed. The fat content (%) was calculated below.

$$\text{Fat content} = \frac{Weight\ of\ fat}{Weight\ of\ sample} \times 100 \quad [4]$$

2.3.5 Total sugar

The total sugar in the pumpkin seed spread was determined by the method of following AOAC 968.28 (2000). The sucrose solution was standardized prior to the analysis of sample. 10g of pumpkin seed spread were combined with distilled water, 100ml and neutralized using 1 N NaOH. Subsequently, the samples were boiled for 1 hour while stirring and adjusted to 500 mL after cooling. The solution was filtered, and a 100 mL aliquot was placed into a burette. Next, a 10 mL blend of copper sulphate solution and alkaline tartrate solution was added to a flask. The flask was warmed on a hot plate for 2 minutes, after which 1 mL of 0.2% aqueous methylene blue solution was added during the heating process, and the volume required for complete titration (2-3 drops) of the sample solution to achieve indicator decolouration was recorded.

2.3.6 Sodium

The sodium concentration was assessed following the method by Wet digestion, which was performed using a combination of 5ml HNO3 and 5 ml H2O2 solution. A sample of 0. 25 g of seaweed jam was incorporated into the prepared solution and subjected to heating at 80 °C for 3 hours. The undissolved solids were filtered out, and the

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filtrates were then diluted to 20 ml. Afterward, the sodium elements present in the solution were analyzed. Standard solutions for sodium were created, and calibration curves for each element were constructed.

2.3.7 Statistical Analysis

The pumpkin seed spread formulation with the highest acceptability and degree of liking was identified by calculating the average value of each sensory characteristic for each formulation during the sensory evaluation test. To discern statistically significant distinctions among the five formulations, including the control, an analysis of variance (ANOVA) are conducting by using Minitab software and Microsoft excel to identify significant variations between the different oil type in pumpkin seed spread. All analyses of the physicochemical characteristics and nutritional value of the pumpkin seed spread are in triplicate. The mean of three replicates and standard deviation is using to express the values of all physicochemical attribute.

3. Result and Discussion

3.1 Sensory Evaluation Test

Table 2 Sensory result of pumpkin seed spread

Sample	Appearance	Colour	Aroma	Spreadability
F1	6.66 ± 1.92a	6.96 ± 1.86a	6.86 ± 1.93a	4.70 ± 2.24c
F2	7.00 ± 1.64a	7.02 ± 1.72a	6.66 ± 1.67a	5.80 ± 1.91bc
F3	6.80 ± 1.77a	6.80 ± 1.89a	6.94 ± 1.54a	5.72 ± 2.11c
F4	6. 36 ± 2.03a	6.94 ± 1.74a	6.80 ± 1.61a	7.52 ± 1.74a
F5	6.96 ± 1.87a	6.96 ± 1.87a	6.80 ± 1.60a	6.88 ± 1.74ab
F6	6.88 ± 2.20a	7.02 ± 2.13a	6.76 ± 1.92a	7.56 ± 1.92a
F7	6.92 ± 2.08a	7.04 ± 1.84a	6.70 ± 1.76a	7.40 ± 1.65a

Table 3 Sensory result of pumpkin seed spread (continue)

Sample	Flavour	texture	Overall acceptance
F1	5.70 ± 2.01^{b}	5.44 ± 2.14^{c}	5.78 ± 1.83^{c}
F2	5.98 ± 2.02^{ab}	5.70 ± 1.93^{bc}	5.92 ± 1.77^{bc}
F3	6.42 ± 1.77^{ab}	5.40 ± 1.70^{c}	6.32 ± 1.71^{ab}
F4	6.64 ± 1.69^{ab}	6.68 ± 1.78^{ab}	6.80 ± 1.49^{ab}
F5	6.70 ± 1.76^{ab}	6.86 ± 1.71^{a}	6.90 ± 1.44^{ab}
F6	7.06 ± 1.92^{a}	7.24 ± 1.83^{a}	7.14 ± 1.78^{a}
F7	6.96 ± 1.69^{a}	7.00 ± 1.84^{a}	7.06 ± 1.62^{a}

A sensory test was conducted on seven pumpkin seed spread samples with oil samples for 50 trained panellists. The tests assessed appearance, colour, aroma, spreadability, flavour, texture, and overall acceptance, with all samples receiving 5-9 scores. The sensory evaluation of seven pumpkin seed spread samples using a 9-point hedonic scale revealed significant differences in spreadability, flavour, texture, and overall acceptance.

Table 4.1 shows the respective mean ± SE sensory value for the 7 samples of pumpkin seed spread through sensory evaluation using 9-point hedonic scale. Statistical showed The attributes of appearance, colour and aroma has no significant different (p<0.05) due the similarity of the seven samples of pumpkin seed spread. The natural pigments present in pumpkin seeds are carotenoids, which improve visual appeal and provide nutritional benefits [7]. The range value appearance which from 6.36 to 7.00 were not given the effect of appearance to the pumpkin seed spread due to similarity in forms. Same with the colour of pumpkin seed spread in between 6.80 to 7.04, showing that the general acceptance of the spreads was good. In general, understanding the effect of colour on consumer preference is crucial for the development of attractive and marketable food products. In general, understanding the effect of colour on consumer preference is crucial for the development of attractive and marketable food products. For the aroma, the value ranged between 6.66 to 6.94. The aroma of pumpkin seed spread, influenced by the natural and roasted seeds, enhances the sensory experience and appeal of the product, contributing to its overall appeal. The combination of palm oil and olive oil can add subtle, complementary aromas that enhance the product's appeal.

In addition, in terms of spreadability, texture, flavour and overall acceptance showed significantly difference ($p>0.05$) due the amount of oils percentage in all seven formulations of pumpkin seed spread. The pumpkin seed spread offered a wide range of distinct and varied tastes and flavours [8]. In this study, the value in the flavour profile of the samples ranged between 5.70 - 7.06 (F1 to F6). The highest score was for F6, with a score of 7.06±1.92. Formulation 6 indicates the highest value due to combination oil used which were palm and olive oil. Olive oil presents a unique, fruity, and somewhat peppery flavour to nut butters, which can improve their overall flavour their profile. According to the Malaysian Palm Oil Council (MPOC), Malaysian palm oil has a neutral flavour and no smell, which is crucial for achieving the appropriate final taste in each product. As a result, it enables the pumpkin seed spreads to have the desired flavour.

In terms of spreadability and texture from all the samples showed inconsistency ranged between the seven samples. Referring to the result above, the score of spreadability in F6 obtained the highest score which was 7.56 ± 1.92 (6% of palm and olive oil) and the lowest score was 4.70 ± 2.24 in F1 (6% of palm oil). F3 obtained the lowest score regarding texture in pumpkin seed spread at 5.40 ± 1.70, while F6 had the highest score of 7.24 ± 1.83. Thus, F6 exhibited a much smoother or more desirable texture compared with F3, whose texture was less desirable. This means that the addition of olive oil to palm oil in F6 improved the spreadability, hence easier to spread on bread, compared to F1 with only palm oil. With suitable oil combining in F6, a smooth texture could be expected and better spreadability hence, the pumpkin seed spread was more pleasant and harmonious in its texture. For the overall acceptability, sample 6 was most preferable by the 50 panellists with highest value 7.14 ± 1.78. Balanced concentration of palm oil and olive oil in this spread has rendered acceptable sensory quality. The spread has received positive. According to the reviews from the panellists, Sample 6 had improved flavour and texture due to the combination of oils, hence a better overall acceptance.

3.2 Physicochemical Properties

The physicochemical analysis conducted on pumpkin seed spread with various oil types in seven different formulations. The analysis covered crucial aspects such as moisture content, pH, total soluble solid and colour. All seven samples were analysed for physicochemical properties, including moisture content, pH, total soluble solid and colour, as indicated in Table 4.

Table 4 Experimental results of Moisture Content, pH and Total soluble solid of pumpkin seed spread with various oil types

Sample	Moisture Content (%)	pH	Total Soluble Solid (°Brix)
F1	2.5 ± 0.02^{b}	5.37 ± 0.05^{ab}	72.22 ± 0.07^{a}
F2	2.79 ± 0.05^{b}	5.23 ± 0.02^{b}	72.28 ± 0.04^{a}
F3	2.56 ± 0.44^{b}	5.56 ± 0.21^{a}	72.39 ± 0.15^{a}
F4	4.11 ± 0.28^{a}	5.52 ± 0.03^{ab}	72.68 ± 0.09^{a}
F5	3.6 ± 0.14^{a}	5.50 ± 0.16^{ab}	72.91 ± 0.68^{a}
F6	3.94 ± 0.51^{a}	5.64 ± 0.05^{a}	72.98 ± 0.40^{a}
F7	3.61 ± 0.13^{a}	5.66 ± 0.10^{a}	72.77 ± 0.65^{a}

Value was expressed in to mean±standard deviation in triplicate.

3.2.1 Moisture content

The moisture is crucial in the food industry for assessing quality, shelf life, and regulatory compliance. Results, summarized in Table 2, showed moisture levels ranging from 2.5 to 4.11. Sample 1 had the lowest moisture at 2.5 ± 0.02, while formulation 4, containing 6% each of palm oil, corn oil, and olive oil, had the highest moisture at 4.11 ± 0.28. Higher oil concentration correlated with increased moisture, enhancing texture and spreadability but also posing risks such as oil separation and rancidity. However, this increased oil concentration may also result in challenges such as oil separation and a greater susceptibility to rancidity. High levels of moisture lead to rancidity, growth of Aspergillus Niger, and development of Mucor species in edible oils that have elevated moisture levels [9]. Among formulations 5, 6, and 7, formulation 6 exhibited the highest moisture at 3.94 ± 0.51, attributed to its oil mix (palm and olive). Olive oil excels in water retention and emulsion stability for softer spreads. In contrast, palm oil offers firmness and shelf stability. In contrast, palm oil offers firmness and shelf stability. However, all of the seven formulations not showed significantly differences in range of moisture content ($p<0.05$).

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3.2.2 pH Analysis

Measuring pH in food and beverage manufacturing offers crucial information regarding its quality, safety, and consistency. The value pH of pumpkin seed spread has no significant difference ($p<0.05$), the result above shows that the pumpkin seed spread not indicates as acidic food. The pH values of the pumpkin seed spreads ranged from 5.23 ± 0.02 (F2) to 5.66 ± 0.10 (F7). These results indicate that the spreads are slightly acidic to neutral, but they do not classify as highly acidic foods (pH < 4.6), which is a critical threshold for microbial safety and preservation [10]. The pH homogeneity between samples shows that they had been produced and processed quite identically, with no significant deviations affecting taste, freshness, or life. However, the fluctuation value of pH probably due to the variations which might have occurred during the actual preparation of ingredients.

3.2.3 Total Soluble Solid (°Brix)

The study analysed the total soluble solid values of seven different pumpkin seed spread formulations, revealing a stable concentration of soluble solids across the samples. The TSS values ranged from 72.22 ± 0.07 to 72.98 ± 0.40 °Brix, indicating a high concentration of soluble solids. All of the pumpkin seed spread sample not showed significant different ($p<0.05$) cause the value of °Brix not showed huge gap between the seven samples even its high compared than typical fruit-based spreads but the value. This indicates consistency in sugar and dissolved solids levels. Honey, which contains 80-85% sugars, has a higher concentration than typical fruit-based spreads. The number of sugars and soluble solids affects the flavour and consistency of the spread. Applying a designated Brix level can influence the product's taste and stability, ensuring it meets the required standards for spreadability and flavour. The TSS values of pumpkin seed-based fruit spreads, for example, were reported between 15.41 and 23.04 °Brix in research, which is comparatively very low in relation to the current study. The level of sugar and soluble solids of it decides the taste and texture of the spread. A specified Brix level applied can affect the taste and stability of the product, ensuring it meets the required standards for spreadability and flavour [11].

3.2.4 Colour Measurement

Table 5 Experimental result of the Colour Measurement in Pumpkin Sees Spread

Sample	Colour values		
	L*	a*	b*
F1	57.14 ± 0.33ab	0.56 ± 0.05f	10.65 ± 0.02cd
F2	56.73 ± 0.07b	0.32 ± 0.02g	10.92 ± 0.06bc
F3	56.13 ± 0.02c	0.85 ± 0.03e	10.23 ± 0.01e
F4	55.48 ± 0.29d	2.17 ± 0.03a	10.34 ± 0.21de
F5	57.40 ± 0.25a	1.13 ± 0.03d	11.07 ± 0.06b
F6	56.75 ± 0.18b	1.39 ± 0.03c	11.21 ± 0.20b
F7	56.05 ± 0.13cd	1.58 ± 0.05b	12.23 ± 0.03a

Value was expressed in to mean±standard deviation in triplicate.

The results showed that the L* value (representing darkness), a* value (representing greenness), and the b* value (representing yellowness) were not significant differences between the seven sample ($p<0.05$). The darkness of the pumpkin seed spreads ranged from least dark to darker, 55.48 ± 0.29 (F4) to 57.40 ± 0.25 (F5). Colour serves as a crucial physical property for consumers and manufacturers in assessing food quality, especially regarding initial appearance. The darkness values (L values) of pumpkin seed spreads range from 55.48 ± 0.29 (F4,) was dark green to 57.40 ± 0.25 (F5,) least dark green, indicating minimal differences in darkness.

The distinct colouration primarily originates from the natural green pigments in pumpkin seeds. Variations in colour may arise from the seed quality, roasting conditions. During roasting, some pumpkin seeds were not turn into dark green due to not being stirred evenly every 20 minutes. This can significantly affect the colour of pumpkin seed. Next, the a-values, influenced by these green pigments, show the lowest at 0.32 ± 0.02 for the F2 formulation, representing stronger greenness. F4's a-value of 2.17 ± 0.03 indicates reduced greenness, potentially due to oil composition. Furthermore, b-values reflecting yellowness could result from natural seed pigments or processing treatments like roasting or blending with sweeteners [12]. However, additional ingredients, such as different oil types are used in the spreads. However, the types of oil. With a greater concentration of oil in the formulation, the natural colour of the oil itself starts to dominate and amplifies the

spread of darkness. Indeed, this darker appearance of spreads that contain more oil is not only due to the intrinsic colour of the oil but also because it enhances the expression of pigments in the formulation. Overall, the colour of the seven samples for pumpkin seed spread was dark green.

3.2.5 Texture Profile Analysis

Table 6 Experimental result of Texture analysis in Pumpkin Seed Spread

Sample	Texture
F1	131.46 ± 11.77^{c}
F2	247.29 ± 13.86^{b}
F3	529.88 ± 56.57^{a}
F4	66.31 ± 4.11^{d}
F5	71.59 ± 0.88^{cd}
F6	22.26 ± 1.58^{d}
F7	21.04 ± 1.20^{d}

Value was expressed in to mean±standard deviation in triplicate.

Hardness and consistency are crucial factors influencing the spreadability of seed butters, it emphasizing the importance of achieving the right balance for optimal spreadability. In the case of pumpkin seed spreads, texture profile analysis (TPA) revealed significant variations in hardness across different formulations, largely determined by the types of oils used [3]. When the hardness is excessively high, it leads to a product that is challenging to spread on food items. Conversely, if the hardness is insufficient, the product will be overly soft and will flow easily. Hardness and consistency are closely related to spreadability; products with too much hardness may be difficult to spread, and those that are too soft may not stick well with food items. Notably, F3, which contained 6% olive oil, exhibited the highest hardness value (529. 88 ± 56. 57), making it notably less spreadable. The spreads with olive oil tended to be firmer compared to those made with palm and corn oil. This can influence the firmness of the spread, however among the seven formulations, the formulation 3 was hard to stir due to hardness [13].

Conversely, F6 and F7 showed the lowest firmness (22. 26 ± 1. 58 and 21. 04 ± 1. 20, respectively), indicating they were the most easily spreadable. Palm oil is one of the most used oils due to its stability and ability not to separate in emulsions. It is semi-solid at room temperature, which could contribute to a creamier nature of spreads [14]. F6 combined palm and olive oil for stability, while F7 used corn and olive oil, resulting in a lighter texture and improved spreadability due to a balanced flavour profile. The blending techniques directly influenced to the desired textures and usability of these spreads.

3.2.6 Nutritional Value

Table 7 experimental result of nutrient content in pumpkin seed spread

Nutrition information	Serving size :100g
Energy	1592 kj
	379 Kcal
Total fat	3.7 g
Total carbohydrates	59 g
Protein	26.7 g
Sodium	36 mg
Total sugar	11.6 g

In terms of nutritional value of pumpkin seed spread, the most suitable sample from the panellist was selected to analyse the spread's nutritional content. Thus, formulation 6 was chosen for the nutritional analysis. Based on the table 4, the energy content of formulation 6 pumpkin seed spread was 379 kcal per 100g of serving size. When comparing the pumpkin seed spread with other commercial peanut butter which is the most popular in Malaysian, Daisy Peanut Butter has 622 per 100g of serving size. Thus, the energy content of these pumpkin seed spread able to be considered as low calorie. This makes it a high-calorie food primarily due to its fat

content. The spread contains 59g of carbohydrates per 100g, a relatively high amount attributed to its ingredients, with carbohydrates playing essential roles in plant physiology [15]. The total fat content in this formulation is 3. 7g per 100g. In contrast, defatted pumpkin seed spread has a much higher fat content of 24. 8g per 100g, suggesting that formulation 6 is a lower-fat choice, appealing to health-conscious consumers. This lower fat content aligns with current dietary trends favouring healthier, low-calorie products [7].

Additionally, the spread contains a notable 26. 7g of protein per 100g, some researcher state that roasted pumpkin seeds are rich in protein, fulfilling 23-56% of daily protein needs [16]. The sodium content is low at 36mg per 100g, making it a healthier option compared to many other spreads. The sugar content is also moderate at 11. 6g per 100g, significantly lower than common fruit preserves, which can exceed 30g per 100g. For instance, many fruits preserves and jams are above 30 grams of sugar per 100 grams, making pumpkin seed spread significantly less sweet. Sugar in food categories sources of sweetness, but also possesses additional features such as water retention, browning, texture alteration and structural enhancement [17]. Thus, this pumpkin seed spread can indicate as low sugar spread and high in protein which can be on the alternative spread those seeking for free nut spread.

4. Conclusion

This study successfully formulated a pumpkin seed spread using various oil types, achieving its research objectives through detailed analysis of physicochemical properties and sensory evaluations of seven formulations. The sensory test discovered that all 50 participants approved the spread based on appearance, colour, scent, flavour, spreadability, and overall acceptability. During the sensory evaluation test, all panellists gave favourable scores ranging from 6 to 9 for all qualities. The most important aspect of the pumpkin seed spread's flavour and texture can be adjusted by altering the ingredients, particularly the salt content and blending time. Among the formulations, the sixth, containing a mixture of palm and olive oil, was the most preferred due to its superior spreadability. Physicochemical analyses indicated that formulations five and six maintained desirable moisture stability, with moisture content typical for oil-based spreads. The pH of the pumpkin seed spread ranged from 5. 23 to 5. 66, classifying it as slightly acidic to neutral. The spread's total ^{o}Brix significantly surpassed that of other seed spreads, ranging from 72. 22 to 72. 98, comparing the TSS values of pumpkin seed-based fruit spreads, were reported between 15.41 and 23.04 °Brix in research, which is comparatively very low in relation to the current study. The level of sugar and soluble solids of it decides the taste and texture of the spread. Pumpkin seed spreads' colour is influenced by natural green pigments, processing conditions, and ingredient variations. darkness and greenness vary slightly, with F2 being the greenest and F4 darker due to multiple oils. Colour variations were affected by natural pigments and processing, with formulation two being the greenest. Thus, in term of firmness, formulation three was the hardest, affecting its spreadability, while six and seven exhibited lower hardness. Formulation 6 indicates the best between all the formulation and has a low energy content of 379 kcal per 100g serving size.

Hence this study successfully showed that the pumpkin seed spread contribute to the alternative of nut spread or butter. Overall, the formulation six indicates the most preferable for consumer especially in terms of its spreadability, texture and flavour. This pumpkin seed spread can be a healthier alternative to nut-free options for consumers. The combination of palm and olive oil is uncommon in the food industry and provides vitamin E, anti-inflammatory properties, and a high protein content. Most importantly, both oils are cost effective and add a distinct flavour to pumpkin seed spread. Thus, Further research suggests developing healthier pumpkin seed spreads using zero-calorie sweeteners, experimenting with microbial and oil separation analysis, and analysing rheology properties for shelf life and rheology properties in pumpkin seed spread production.

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Conflict of Interest

There is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nurul Shahanim Baharudin, Faridah Kormin;* ***data collection****: Nurul Shahanim Baharudin;* ***analysis and interpretation of results:*** *Nurul Shahanim Baharudin, Faridah Kormin;* ***draft manuscript preparation:*** *Nurul Shahanim Baharudin, Faridah Kormin. All authors reviewed the results and approved the final version of the manuscript.*

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