# Influence of Roasting time and ingredient optimization on the Nutritional, Sensory and Storage Quality of Sesame-Honey spread

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**ABSTRACT:** *The study examined the impact of different sesame-honey ratios and roasting duration on the nutritional profile, sensory characteristics, and shelf life of sesame-honey spread. Twenty-five treatment combinations were applied to 5 sesame-honey ratios ranging from 90:10 to 50:50. Roasting times were 5 to 25 minutes for each ratio. A formulation processing optimization design of 5 × 5 was used to study the relationship between sesame-honey spread samples. The proximate analysis, free fatty acid (FFA) content, sensory acceptability, and microbiological quality were evaluated. The formulation ratio significantly affected the protein (6.57-16.47%), fat (39.90-66.87%), and carbohydrate contents (9.26-39.90%) ($P < 0.05$), while roasting time significantly affected fat content and FFA development ($p < 0.05$). A sensory evaluation with 50 untrained panelists showed that the formulations were very different in terms of taste, smell, texture, and overall acceptability ($p < 0.05$). The highest rate of sensory acceptability was scored for the 70:30 sesame-honey formulation (7.86 ± 1.18). Free fatty acids (FFA) increased from 0.12% at week 0 to 0.28% under room temperature conditions and 0.30% under elevated temperature conditions during 8 weeks of storage. Total viable count remained between $1.2 \times 10^2$ and $1.7 \times 10^2$ cfu/g throughout the storage period, which falls within the acceptable limits for ready-to-eat spreads. The findings outlined that formulation ratio and roasting time play a key role in enhancing the nutritional quality, sensory acceptance, and storage stability of sesame-honey spread.*

***Keywords**: Sesame-honey spread, roasting optimization, value addition, sensory quality, storage stability*


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## INTRODUCTION

The cultivation of sesame (*Sesamum indicum*) covers Asia, Africa, and parts of Latin America. The growing environment for sesame is adaptable to different climate conditions and varieties of soil. Sesame is recognized as an important cash crop for farmers (Anyogu et al., 2024). The increase in the global demand for safe and nutritious foods increases sesame's attractiveness as a sustainable crop option that assists farmers in improving their economic well-being and providing health benefits to consumers (Chatterjee & Tewari, 2024). Sesame is widely incorporated in many processed food to enhance its nutritional and functional properties (Atingah, 2021). The total global output of sesame seeds was estimated at 7.7 million tonnes for 2020, which showed that the crop had already become a basic element of the food systems of different cultures (Oboulbiga et al., 2023).

In Africa, sesame is of great nutritional value, and the fat content of 100 grams of the seed ranges from 52 to 57 grams (Sanni et al., 2022). A large percentage of sesame harvested in Africa is exported in its raw state, and this reflects unexploited potential in sesame farming. There is also very minimal investment in the production of value-added products such as spreads and pastes (Muthoni & Shimelis, 2025). The raw sesame export restricts the rural population's income, especially, the small-scale farmers who cultivate most of the crops in the area (Gazali et al. 2022). Despite the growth of the African sesame industry, it is faced with numerous challenges that require solutions. These include facilities for processing, a general low level of understanding of sesame's nutritional and health benefits, and the general perception that consumers have about sesame as an export crop. These attitudes have made it difficult to market sesame as a food item that should be used regularly at home (Dossa et al., 2022 and Kusse et al., 2022). In some African countries, growing sesame serves for both household consumption and selling; thus, it highly contributes to income generation and food security, especially in semi-arid areas (Anyogu et al., 2024; Wei et al., 2022). Flavour and aroma enhancement is another part of the peculiar processing treatment that further captivates consumer interest in sesame products via roasting (Chatterjee & Tewari, 2024). Roasting methods vary widely, particularly for smaller producers; therefore, there is generally an inconsistency with the final quality of the product produced. Recently, products containing sesame have been combined with honey or another type of natural sweetener to satisfy the growing consumer demand. Although this is a positive trend, not much is known regarding how roasting conditions and the way ingredients are combined impact the overall product quality (Atingah, 2021).

Within Ghana, sesame is primarily grown in the northern regions, where increasing attention is being placed on value-added products and small-scale processing (Anyogu et al. 2024). Sesame–honey spreads are beginning to appear as alternative breakfast and snack products. However, production methods are largely informal. The determination of roasting times and ratios of ingredients for roasted sesame is generally made based on practical experience rather than on empirical data. Depending on the method used for preparation and storage of roasted sesame, this experience can produce variations in flavour, texture and shelf life, especially about those products that are usually stored at ambient temperature in tropical climates (Atingah, 2021).

Although some researchers have conducted investigations into the nutritional and functional profiles of roasted sesame seed and paste products (Chatterjee & Tewari, 2024; Anyogu et al., 2024), these studies have tended to focus on either roasting (e.g., temperature, time) or formulation (formulation ratios) relative to each other rather than on both variables simultaneously. Despite the high nutritional content and indigenous availability of sesame seeds in Ghana, their utilization for spread production is low; consumers rely on peanut-based spreads characterized by safety-related problems and limited shelf life. A limited number of studies have investigated the integrated effects of roasting time and sesame–honey formulation ratios on the sensory quality and shelf stability of sesame butter products in tropical sub-Saharan African ambient conditions. In the current literature, processing and formulation factors are typically considered independently, which restricts practical optimization. This limited empirical knowledge becomes an impediment in the establishment of uniform and safe sesame–honey spread products that are also acceptable to the consumers. Therefore, the possibility of value addition, among others like food safety enhancement and higher sesame utilization, is not well explored. This study attempted to investigate the combined influences of roasting time and sesame-honey formulation ratio on the nutritional, sensory, and storage stability properties of sesame-honey spread. The results are expected to support better processing decisions for sesame-based spreads produced under conditions like those in Ghana.

## MATERIAL AND METHODS

### Research design

The study used a formulation–processing optimization design, rather than a complete factorial experimental design, which combined both variable--in this case, roast time and sesame–honey ratio--together across five designs (TT0–TT4). These treatments were chosen to represent realistic processing conditions that typically applied to small scale and artisanal sesame spread production. Thus, each design represents a unique processing condition with an associated roast duration and ingredient ratio (Montgomery, 2020). The goal of the study was to assess the combined impact of roasting intensity and formulation on the nutritional composition, sensory characteristics and storage stability, not to evaluate the separate main effects of each variable. Therefore, this design mirrors the practical emphasis of the study and was intentionally stated to prevent incorrect interpretation. All the analyses conducted were performed in the well-equipped Food Science Laboratory at Kwame Nkrumah University of Science and Technology.

**Source of Raw Materials**

Sesame seeds were purchased from farmers in northern Ghana, where sesame is grown extensively. The other ingredients, which include honey, vegetable oil, and salt, were obtained from trustworthy local supermarkets. This was done to ensure the freshness and quality of the ingredients used. The choice of ingredients also allowed the study to reflect the real consumer behaviours and supported local producers. All raw materials were thoroughly cleaned and processed one at a time, where they were checked for stones and broken seeds and other debris to ensure only clean and quality materials went into the final product.

**Preparation of Sesame Seeds for Spread**

Each roasting batch consisted of 300 g of sesame seeds. The seeds were then roasted under controlled conditions according to the experimental treatments after their cleaning and manual sorting, which included removing stones, dust, and damaged kernels. The roasting was carried out at 120°C, but for different duration depending on the sample code: sample TT0 was roasted for 5 minutes, TT1 for 10 minutes, TT2 for 15 minutes, TT3 for 20 minutes, and TT4 for 25 minutes. The roasting treatments were carefully selected to expose the seeds to different heat levels to observe how these variations influence flavour, colour, and overall spread quality—while aligning with recommendations from sesame-processing literature that emphasize the use of moderate temperatures (Wei et al., 2022; Sanni et al., 2022). At the end of roasting, the seeds were cooled down to room temperature, as the effect of hot milling could lead to the loss of nutrients in the seeds. A high-speed Panasonic MX-151SG1 electric grinder with stainless-steel blades was used to convert the cooled seeds into a smooth paste. The finely ground sesame paste, together with the other ingredients as per the experimental plan, was to be combined with measured amounts of natural honey, sunflower oil, and salt. The period of mixing was sufficient to obtain a uniform and spreadable texture, after which cooling occurred. The sesame seed spreads were sealed in airtight containers for the sensory and laboratory analyses.

**Mixing and formulation of sesame seeds spread**

The method for preparing sesame paste was reported by Anyogu et al. (2024) with minor modifications according to the major substrate established by the assigned formulation (Table 1). Roasting and grinding resulted in the paste, which was then mixed with other ingredients. The paste was first mixed with 100 ml of sunflower oil and 1 g of salt, then thoroughly blended in a food processor until it was creamy and smooth. This ensured that the oil and salt were uniformly incorporated throughout the mixture. Next, honey was incorporated (in different amounts according to formulation: 10 g, 15 g, 20 g, or 25 g per batch) and mixed again until the spread achieved a uniform, homogeneous consistency. This two-step mixing procedure helped to ensure even distribution of both fat and flavour throughout the paste, yielding a smooth, spreadable texture. After mixing, the sesame spread was transferred into sterilized plastic jars, sealed with aluminum foil, and stored at –12 °C until further analyses (sensory evaluation, physicochemical tests, and storage stability). This technique is based on some practices already discussed in recent sesame-processing studies, where it has been emphasized that quality mixing and proper formulation are the key to getting sesame pastes or spreads that are stable and acceptable to consumers (Wei et al., 2022). Table 1 shows the ingredient formulation.

**Table 1:** Proportions of Sesame and Honey spread (Atingah, 2021).

| Sample code | Roasted Sesame seed | Honey (ml) | Sunflower oil | Salt | Processing time (minutes) |
|---|---|---|---|---|---|
| $TT_0$ | 90g | 10 | 50 ml | 0.5 g | 1 |
| $TT_1$ | 80g | 20 | 50 ml | 0.5 g | 2 |
| $TT_2$ | 70g | 30 | 50 ml | 0.5 g | 3 |
| $TT_3$ | 60g | 40 | 50 ml | 0.5 g | 4 |
| $TT_4$ | 50g | 50 | 50 ml | 0.5 g | 5 |

$TT_0$ *(90% Roasted sesame seed, 10% Honey)*, $TT_1$ *(80% Roasted sesame seed, 20% Honey)*, $TT_2$ *(70% Roasted sesame seed, 30% Honey)*, $TT_3$*(60% Roasted sesame seed, 40% Honey)*, $TT_4$ *(50% Roasted sesame seed, 50% Honey),*

**Physicochemical Properties of the Sesame Spread**

The physicochemical properties of the sesame spreads were measured to ascertain their nutritional quality, stability, and sensory characteristics to the consumer. All analyses were conducted in duplicate using standard AOAC (2019) methods.

**Moisture Content and Total Solids**

About 5 g of the sample was placed in a pre-weighed dish and dried in an oven at 105 °C for 5 hours. The dish was cooled in a desiccator and weighed. Drying, cooling, and weighing were repeated until a constant weight was achieved. Moisture content and total solids were calculated as follows:

$$\%\ \text{Moisture} = \frac{\text{Initial weight} - \text{Dried weight}}{\text{Initial weight}} \times 100$$

### Ash Content

Five grams of sample were placed in a pre-tared crucible and ignited in a muffle furnace at 600 °C for 2 hours. After cooling in a desiccator, ash content was calculated as:

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Initial sample weight}} \times 100$$

### Fat Content

Fat was extracted from 5 g of dried sample using a Soxhlet extractor with 150 ml petroleum ether (B.P 40–60 °C) for 4–6 hours. The solvent was evaporated, and the fat/oil residue was weighed. Fat content was calculated as:

$$\% \text{ Crude Fat} = \frac{\text{Weight of extracted fat}}{\text{Sample weight}} \times 100$$

### Crude Fiber

Two grams of defatted sample were digested in 1.25% $H_2SO_4$ and 1.25% NaOH, each for 30 minutes under reflux, filtered, dried at 105 °C, cooled, weighed, and ashed. Crude fiber content was calculated as:

$$\%\text{Crude Fibre} = \frac{\text{Weight before} - \text{Weight after ashing}}{\text{Sample weight}} \times 100$$

### Protein Content

Protein was determined using the Kjeldahl method. Two grams of the sample were digested with concentrated $H_2SO_4$ and a selenium catalyst. Ammonia was distilled and titrated with 0.1 N HCl, and total nitrogen was determined. Protein content was calculated using:

$$\% \text{ Crude Protein} = \%N \times 6.25$$

### Carbohydrate Content

Carbohydrates were calculated by difference:

$$\%\text{Carbohydrate} = 100 - (\%\text{Moisture} + \%\text{Ash} + \%\text{Crude Fat} + \%\text{Crude Protein} + \%\text{Crude Fibre})$$

### Determination of Total Sugar

The total sugar present in the sesame -honey spread was measured by the anthrone method described by Hedge and Hofreiter (1962), with slight modifications to the process. This last stage of the laboratory preparations involved dissolving 2 g of the anthrone using the concentrated sulphuric acid ($H_2SO_4$) reagent, referred to as the anthrone reagent. The stock glucose solution was prepared to a concentration of 100 µg/mL, while the dilution levels ranged from 10 to 100 µg/mL to produce a calibration graph. For the analysis, a volume of 1 mL of the glucose standard and sample solutions was pipetted into clean test tubes. The standards were prepared at concentrations of 2, 5, 10, and 100 µg/mL, alongside an undiluted sample. Moreover, a blank sample, with the addition of 1 mL distilled water, was to be performed in the procedure. Each tube was then treated with 4 mL of anthrone reagent solution, gently mixed, and covered with glass marbles. The test tubes were placed in a boiling water bath and heated for 10 minutes, after which they were allowed to cool to room temperature. Absorbance readings were subsequently taken at a wavelength of 620 nm using a spectrophotometer, with the blank used to zero the instrument before measurement. The graph for the standard calibration curve was plotted with glucose concentrations along the x-axis and the corresponding absorbance along the y-axis. The total sugar content of sesame seed spreads was determined above using the calibration graph, and the results were expressed in mg of glucose per gram of samples.

## Microbial Analysis

### Determination of Total Aerobic Count (TAC)

The total count of aerobic gram-positive and gram-negative bacteria was performed through the spread plate technique, where a sample of 100 µL of each dilution was plated onto a plate count agar medium, following the method adapted by Libby et al. (2021). Plates were dried in air for a period of 15 minutes at room temperature and then inverted and incubated at a temperature of 37°C for a period of 24 hours. The colonies formed after incubation were counted in terms of colonies per gram (CFU/g).

### Determination of Total Coliform Count (TCC)

The number of coliforms was enumerated using the MacConkey Agar according to Osei et al (2024) Method. One hundred microliters of each dilution were plated and evenly spaced. The plates were inverted and incubated at 37°C for 24 hours. Red and pink colonies were recorded as coliforms and counted per gram. If the total colonies counted in the sample are represented by 'x,' then the total

### Determination of *Staphylococcus aureus*

Detection of Staphylococcus aureus was done using the Mannitol Salt Agar (MSA), and the process followed the Libby et al (2021) method. Each sample dilution was plated and evenly spaced. The plates were incubated at 35°C for a period of 24 hours, and colonies that appeared yellow in color were quantified and recorded as S. aureus in CFU/g.

**Determination of *E. coli***

The detection of *E. coli* involved the use of Brilliant *E. coli* Agar based on Libby et al (2021). A 0.1 mL volume of each dilution of the samples was plated and incubated at 37°C for a period of 24 hours. The presence of purple colonies confirmed the presence of *E. coli*.

**Determination of *Salmonella typhi***

Identification of Salmonella isolates was done through the conventional method and selective agents used for cultivation. It was specific for sesame-honey spread. About 5 g of each sample was combined with 45 mL of 1% peptone water and incubated for overnight pre-enrichment at 37 °C. The next day, 100 µL of pre-enriched culture was transferred aseptically into selective enrichment broth and allowed to incubate for 24 hours. The samples were then plated on selective agar media, and colonies exhibiting characteristic morphology-black centers on XLD and red colonies on BGA- were scored as Salmonella (Libby et al., 2021; Osei et al., 2024).

**The Determination of the Shelf Life**

The Determination of the shelf life of the sesame-honey spread was evaluated based on indicators of microbiological and physicochemical properties following the guidelines of Libby et al (2021). The indicators comprising the microbiological properties include total aerobic count, total coliforms, yeast, and mould counts, while the physicochemical properties include moisture and free fatty acid (% content. The samples were maintained at two temperature conditions: room temperature (25°C) and higher temperature (45°C) for 8 weeks. The analyses were performed at 8-day intervals. The data were analyzed with the Statgraphics Centurion software, and the shelf life of the samples was determined through simple and multiple regression analyses to assess the growth trends in the microorganisms and physicochemical changes.

**Sensory Evaluation**

Sensory evaluation of the sesame-honey spread was conducted using 50 untrained panelists who served as food tasters. Each panel member was supplied with a 20 g sample of the product using a white disposable plastic cup, together with a spoon. The panel members were also given sensory evaluation cards for the assessment of particular attributes of the products, which included colour, aroma, texture, smoothness, spreadability, taste, and acceptability. Each sample contained 5g of spread, dispensed on a white disposable plate, together with cream cracker savoury biscuits. Each plate carried the alphabet lettering codes TT0 to TT4. The panelists assessed the spreadability of the samples by spreading the samples on a cracker biscuit and noting the results on a ballot sheet. The panelists then used the nine-point hedonic scale for assessing the overall acceptability of the samples, where a score of “1” represents “dislike extremely” and “9” “like extremely,” according to the guidelines given by Resurreccion (2018). The average score for each attribute was determined, and the results were also analyzed using descriptive statistics, such as standard deviation and coefficient of variation, for the analysis of panelist variability to assess consistency and variability among the panelists’ responses.

**Statistical Analysis**

Statistical analyses were performed using two different statistical analysis programmes to yield the most precise and most meaningful results. The programmes used for statistical analyses were; GraphPad Prism, version 5.0, the most employed statistical hypothesis test (one-way and two-way ANOVA) software, was used to test significant differences between treatment groups at a 95% confidence level. The study also used Statgraphics Centurion to conduct multiple regression analysis and trend visualization of the growth of microbes and physicochemical changes during the storage period of the samples. All measuring processes for the physicochemical analyses (i.e., proximate composition, free fatty acids, and total sugars) were performed in duplicate. All microbiological assessments were performed in triplicate at each time point and every condition during the storage period. Fifty (50) untrained panelists evaluated each sample separately for sensory analysis, with each participant providing their individual review of all formulations tested. The reporting of the replicated data demonstrates that considerable attention was devoted to achieving accurate and reproducible findings.

**Ethical considerations**

This study was conducted based on the ethical principle for food science and sensory studies. All laboratory analyses were conducted in accordance with the practice of safety and quality assurance to ensure accuracy and validity.

The sensory analysis was purely done on a voluntary basis, and the purpose and identity of the study were disclosed to all panelists before taking part in the evaluation. Verbal consent was obtained from all study participants, and no personal or identifiable data were collected, ensuring anonymity and confidentiality. Sensory-tested sesame-honey spreads were hygienically made with good-quality food-grade ingredients, and all tested samples were microbiologically acceptable for consumption.

These were all nonvulnerable subjects, and the study had no apparent or potential risk for the participants’ health.

## RESULTS AND DISCUSSION

### Proximate Analysis

According to Table 2, various trends were found in the different levels of formulation. With a declining sesame level from TT0 to TT4, the fats and proteins decrease correspondingly with the increase in carbohydrates and moisture. A good example is the formulation TT0, which exhibited the most significant reductions in fat, approximately 66.9%, and protein, around 16.5%. In contrast, the formulations with lower sesame content, particularly the honey variants, displayed reduced fat levels, specifically about 39.9%, as well as lower protein content. The formulations exhibited increased carbohydrate levels of 39.9% along with a modest rise in moisture, which ranged from approximately 3.6% to 6.9%. These values seem within the ranges reported for sesame seeds and related products. For instance, Seid and Meharil (2022) reported that embryos of raw sesame seeds had 52.9% fat and 23.5% protein, whereas Hou et al. (2018) indicated fat contents ranging from 51.8% to 61.6% and protein from 16.1% to 18.9% in processed sesame pastes. The reported crude fat content varied between 44.4% and 50.8%, while protein levels ranged from 16.1% to 18.9%. Furthermore, across different sesame cultivars, fat content was observed between 44.4% and 50.8%, with protein varying from 14.4% to 21.5% (Mulate and Hayelom, 2020).

The compositional characteristics of high sesame content lead to increased fat/protein levels via the naturally occurring oil/protein found within the seeds as well as any additional oil produced during the roasting process. The high sesame content causes an increase in fat and protein levels since sesame seeds have oil (fat) as well as protein, while roasting may allow leaching of some additional oil. One would think that roasting, through a combination of partial denaturation of protein and migration of oil to the surface, produces readings of fat slightly higher than those obtained for sesame-based products. In contrast, in honey-sesame products, higher honey content allows sugar and moisture to dilute sesame's contribution to the spread, thus making it sweeter and softer. The distinction has functional implications whereby protein-fat-rich oil (fat) formulations are energy-dense and may serve as protein boosters, while honey-sesame formulations may be used for sweet spreads. Although the difference in moisture content is low, it is significant, as it directly influences water activity, which is crucial for both microbial stability and shelf life. Consequently, wet formulations that contain higher levels of carbohydrates may necessitate further investigation into the safety aspects of water activity and storage stability. High-fat sesame-rich spreads also pose a risk of oxidative rancidity in the long run; hence, care needs to be taken in packaging, storing, and, wherever applicable, using antioxidants (Mahajan et al., 2025). However, it is important to note some limitations of this study. The variation in composition may not solely relate to the sesame-to-honey ratio; factors involved in the processing of these products, varying levels of moisture absorption, and possible non-uniformity all have an influence (Mulate and Hayelom 2020). Additionally, water activity was not directly measured in this study. Therefore, predictions about the microbial stability of each formulation used in this study are incomplete. These concerns should be thoroughly examined in future research aimed at optimizing formulations and enhancing the self-life of sesame-honey products. Overall, the results of this study indicate that the findings of each study must be interpreted based on the specific type of study being conducted or investigated by the results presented in that study. In general, high-nutrient and protein-rich bases will have a greater concentration of sesame in their formulation than bases that are sweeter and softer, which will use more honey. A mechanistic understanding of how the roasting process primarily affects the release of oils from nuts as well as moisture from nuts provides an approach to developing successful formulation strategies. Table 2 presents the proximate composition of the sesame-honey spread.

### Free Fatty Acid and Total Sugar Composition

The free fatty acid (FFA) and sugar levels in the sesame-honey spreads (Table 3) tended to increase with a combination ratio. Sample TT0, which had a significant sesame content, exhibited relatively high free fatty acid (FFA) levels of approximately 0.19% and lower sugar content at around 8.06%. This observation reflects the sample's elevated oil content. On the other hand, TT1~TT4 samples high in honey content show low FFA levels (~0.12~0.16%) and high sugar contents (~8.56~10.19%) depending on the quantity of honey added. These also tend along expected lines since increasing proportions of sesame would be expected to increase the amount of fat and oil but not sugars, whereas

**Table 2:** Proximate Composition of spread *(*Atingah, 2021*).*

| Sample | Moisture | Ash | Protein | Fat | Fibre | CHO |
|---|---|---|---|---|---|---|
| **$TT_0$** | $3.64\pm0.01^a$ | $4.63\pm0.29^d$ | $16.47\pm1.60^e$ | $66.87\pm0.51^c$ | $5.78\pm1.39^e$ | $2.61\pm0.85^d$ |
| **$TT_1$** | $4.54\pm0.17^d$ | $3.38\pm0.09^b$ | $12.17\pm0.16^a$ | $64.69\pm0.06^a$ | $5.39\pm0.26^a$ | $9.83\pm0.04^a$ |
| **$TT_2$** | $5.84\pm0.28^c$ | $2.91\pm0.09^c$ | $11.45\pm0.48^d$ | $53.92\pm0.71^d$ | $5.30\pm0.86^d$ | $20.56\pm0.70^c$ |
| **$TT_3$** | $6.29\pm0.12^e$ | $2.95\pm0.01^a$ | $6.57\pm0.26^c$ | $39.90\pm0.19^b$ | $4.40\pm0.54^b$ | $39.90\pm0.20^b$ |
| **$TT_4$** | $6.87\pm0.12^b$ | $2.42\pm0.09^c$ | $9.64\pm0.04^b$ | $51.10\pm1.09^e$ | $4.73\pm0.69^c$ | $25.23\pm1.95^e$ |

*Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). Keys:* **$TT_0$** *= (90g Sesame seed, 10g honey, 5mins roasting time),* **$TT_1$** *= (80g Sesame seed, 20g honey,10mins roasting time)* **$TT_2$** *= (70g Sesame seed, 30g honey, 15mins roasting time)* **$TT_3$** *= (60g Sesame seed, 40g honey, 20mins roasting time) and* **$TT_4$***= (50g Sesame seed, 50g honey,25mins roasting time).*

**Table 3:** Free fatty acid and total sugar content of spread (Atingah, 2021).

| Sample | Free fatty Acid | Total Sugars |
|---|---|---|
| **$TT_0$** | 0.19±0.09[d] | 8.06±0.19[d] |
| **$TT_1$** | 0.12±0.01[a] | 9.27±0.09[c] |
| **$TT_2$** | 0.12±0.00[a] | 8.56±0.00[a] |
| **$TT_3$** | 0.16±0.02[c] | 10.19±0.05[b] |
| **$TT_4$** | 0.15±0.03[b] | 8.64±0.06[c] |

*Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). Keys:* **$TT_0$** *= (90g Sesame seed, 10g honey, 5mins roasting time),* **$TT_1$** *= (80g Sesame seed, 20g honey,10mins roasting time)* **$TT_2$** *= (70g Sesame seed, 30g honey, 15mins roasting time)* **$TT_3$** *= (60g Sesame seed, 40g honey, 20mins roasting time) and* **$TT_4$***= (50g Sesame seed, 50g honey,25mins roasting time)*

increasing proportions of honey will increase sugars but not fats and oils. Mechanistically, the variations can be attributed to the combined effects of roasting, blending, the ratio of the ingredients. Roasting, aside from enhancing oil extraction from sesame seeds, can cause a slight hydrolysis of lipids, hence increasing the amount of free fatty acids in the sesame-based products. The blending process and ratio of honey could influence the sugar content distribution for a product. Specifically, sesame seeds vary from each other with regard to intrinsic factors such as oil and protein composition, and these characteristics will have an impact on the nutritional properties of the products produced from those sesame seeds. Some of the studies examining sesame-based products indicate that all ingredients other than sesame seeds used in this process and the sweetening agents added are associated with higher levels of sugar in the resulting food product. Sesame seeds, however, are the primary source of both fat and protein (Atingah, 2021; Mijena, 2017; Aboudou et al., 2020). From a nutritional and formulated product use standpoint, the above results make it possible to outline important design parameters for the product. Sesame-based spreads can be considered more energy-rich and protein-rich and hence suitable for nutritional applications such as protein supplements and energy-rich foods. Honey-based spreads, with higher levels of sugars and hence energy, are suitable for consumption from the taste standpoint. The moderate levels of FFAs in all samples indicate that the spread contains high-quality oil. It can be concluded that products might be formulated when a proper ratio is applied in balancing sesame and honey components to satisfy specific requirements in terms of nutrition and functionality. The product could be tailored to be nutrient-dense, having a higher fat and protein content, or to be sweeter and more carbohydrate-rich. Some other processing variables related to sesame roasting might also be important in influencing oil values. Nutritional and functional implications of the findings have been very apparent in product development. Sesame-based products are very fattening, contain high amounts of plant-based lipids and protein, and can therefore be ideal for specialized use in products of interest such as protein supplements. Honey-based products are very sweet and contain high amounts of carbohydrates and, therefore, are perfect for consumers looking for a spread merely for the taste. The low FFA content in all the products indicates that their oil is of high quality. This data indicates the potential for the sesame and honey mixture to be adjusted to fulfil different nutritional needs. The mixture can be developed for a nutrient-dense and high-fat, high-protein product. The mixture can likewise be developed to become a sweet product.

Additionally, the roasting time and the blending process may further affect the mixture's nutrients. The sesame and honey mixture composition may therefore be adjusted to affect the nutritional and functional properties. Table 3 reveals the free fatty acid and total sugar content of the spread.

## Sensory properties

Table 4 shows that all sesame-honey spreads recorded positive responses, as their mean scores for TT0, TT1, TT2, TT3, and TT4 exceeded 7 on all attributes of colour, aroma, taste, softness, spreadability, smoothness, and acceptability. The mid-range spread, TT2 (70g sesame & 30g honey), scored higher on most characteristics, implying that its balance between the nutty sesame and

**Table 4:** Sensory properties of the spread (Atingah, 2021)

| Sample | Colour | Aroma | Appearance | Softness | Spreadability | Smoothness | Overall acceptability |
|---|---|---|---|---|---|---|---|
| **$TT_0$** | 6.92±1.48[a] | 7.08±1.35[a] | 7.32±1.33[c] | 7.66±1.081[c] | 7.30±1.62[c] | 7.38±1.11[c] | 7.48±1.50[a] |
| **$TT_1$** | 7.04±1.44[a] | 7.10±1.36[b] | 7.08±1.28[a] | 7.29±1.30[a] | 7.67±1.08[a] | 7.25±1.61[a] | 7.19±2.06[a] |
| **$TT_2$** | 6.92±1.53[a] | 7.57±1.39[c] | 7.55±1.25[b] | 7.98±1.21[b] | 7.53±1.69[b] | 7.45±1.47[b] | 7.86±1.18[b] |
| **$TT_3$** | 7.47±1.31[a] | 7.18±1.72[c] | 7.27±1.46[b] | 7.25±1.53[b] | 7.59±1.19[b] | 7.49±1.10[b] | 7.16±1.30[a] |
| **$TT_4$** | 7.39±1.44[a] | 7.27±1.34[c] | 7.49±1.26[b] | 7.37±1.34[b] | 7.39±1.20[b] | 7.25±1.32[b] | 7.25±1.67[a] |

*Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). Keys:* **$TT_0$** *= (90g Sesame seed, 10g honey, 5mins roasting time),* **$TT_1$** *= (80g Sesame seed, 20g honey,10mins roasting time)* **$TT_2$** *= (70g Sesame seed, 30g honey, 15mins roasting time)* **$TT_3$** *= (60g Sesame seed, 40g honey, 20mins roasting time) and* **$TT_4$***= (50g Sesame seed, 50g honey,25mins roasting time)* sweet honey was optimum. However, despite recording relatively lower scores on some characteristics, both the high sesame spread (TT0) and the high honey spread (TT4) recorded scores that fell in the acceptable ranges, signifying general consumer satisfaction with all spreads. These results are in agreement with Atingah (2021); Mohammed Sdiq et al. (2025); Abughous et al. (2025); Yin et al. (2020); and Jin et al. (2022) that a moderate amount of sugar addition could improve texture as well as flavours while causing no deterioration in either colour or aroma of sesame. spreads.

These differences in formulation could be due to sesame-to-honey proportions and processing. Notwithstanding, higher sesame (TT0) contributed to a tougher texture with a darker colour, which mildly compromised smoothness and spreadability, while higher honey content (TT4) enhanced sweetness and texture, although it might have mildly impacted aromatic balance. A similar trait was reported in sesame tahini paste and other nut pastes, where sesame-to-nut ratios and processing also significantly affect texture, flavour, and consumer preference (Okwunakwei et al., 2025; Hou et al., 2018). Furthermore, when sesame seeds were processed, the extent of oil released increased, causing change in sugar distribution.

In addition, the inheritance of oil and protein is highly correlated with seed size (Yin et al., 2020), which may result in subtle differences in the sensory attributes among samples. These considerations also have implications for new formulation development, showing that a moderately honey-added formula (TT2) offering an intermediate taste and texture balance is the formulation with the most promise in terms of consumer uptake. Products with higher sesame content may satisfy consumers with a stronger nutty taste, while honey-sweeter products will satisfy consumers in search of sweet products. On the other hand, the results of the study have indicated that sesame-to-honey ratios and processing can present a product that satisfies a wide range of consumer desires, which articulates the reality that sensory analysis has significant application in creating products with prevalent market acceptability among consumers (Atinga, 2021; Dossou et al., 2024; Wang et al., 2024). Results are displayed in (Table 4).

**Sesame-honey Spread's most important Sensory Attribute**

As demonstrated in Table 5, the study results indicate that aroma and smoothness were the most important sensory attributes the consumers considered in choosing the sesame-honey spread. The highest score was allotted to aroma, and smoothness was rated only slightly lower. Thus, the focus of consumers was completely shifted away from taste and directed mainly more onto aroma and mouthfeel. Appearance, in contrast, was rated lower while taste-wise was completely opposite. The other properties, such as colour, spreadability, softness, and overall acceptability, had relatively similar and moderate ratings. This trend indicates that consumers relied most heavily on freshness, roasting quality, and texture cues. Taste has relatively low importance attached to it, indicating that there might be some limitation in flavour balance that may be due to formulation differences among the treatments. Emphasis on aroma and smoothness is paramount because these attributes create a first impression of spreads and also guarantee a repeated consumption pattern. Aroma is supposed to indicate adequacy of roasting and general freshness, while smoothness generally indicates proper processing and proper release of oils. Therefore, such traits are extremely important for the acceptability and market potential of a product in overall terms. The finding corroborates with the previous studies of sesame-based spreads in which the consumers' preference was dominated more by texture and aroma than by taste or sweetness (Atinga, 2021; Mijena, 2017). The differences in the sensory properties could be due to differences in roasting time and treatment of honey concentration. Longer roasting makes aroma formation better due to flavour-forming reactions, but increases in honey contents improve smoothness quite often but would lower the intensity in terms of natural sesame flavor. Sometimes, very high amounts of sugar could mask typical sesame taste leading to a lower score. However, these results reiterate the importance of the roasting conditions and the amount of ingredients used in the production of a sesame spread that combines good aroma and smooth texture with acceptable flavour to enhance its acceptance by consumers and thus open the way for future product

**Table 5:** Most important sensory attribute of spread to consumers (Atingah, 2021).

| Sensory attribute | Frequency | Percentage (%) |
|---|---|---|
| Colour | 5 | 10 |
| Aroma | 12 | 24 |
| Appearance | 6 | 12 |
| Taste | 2 | 4 |
| Softness | 4 | 8 |
| Spreadability | 5 | 10 |
| Smoothness | 11 | 22 |
| Overall acceptability | 5 | 10 |

*Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). Keys:* **$TT_0$** *= (90g Sesame seed, 10g honey, 5mins roasting time),* **$TT_1$** *= (80g Sesame seed, 20g honey,10mins roasting time)* **$TT_2$** *= (70g Sesame seed, 30g honey, 15mins roasting time)* **$TT_3$** *= (60g Sesame seed, 40g honey, 20mins roasting time) and* **$TT_4$***= (50g Sesame seed, 50g honey,25mins roasting time).*

development. Table 5 shows the results of most important sensory attributes of the spread.

## Shelf Life of Sesame–Honey Spread using Microbiological and Physicochemical Indicators

From the microbiological safety analysis shown in (Table 6), the sesame-honey spread satisfies all the specified safety and quality criteria. In the total viable count (less than 30 CFU/g) and total coliform count (less than 10 CFU/g), the results are quite lower compared to the permissible values of 1.0 × $10^4$ CFU/g and 1.0 × $10^2$ CFU/g, respectively, which indicate a significantly low microbial load. No pathogen like *E. coli*, *S. aureus*, or *S. typhi* was detected in the collected sample; hence, the pest distribution system is microbially safe. Yeast/mould cells: Not detected in sample: 0.00 CFU/g yeast/mould cells. This level of detection is below permissible limits and indicates no microorganisms were present from spoilage. There were no indications of any pathogenic or spoilage microorganisms; hence, the sesame and honey spread was free from hygienic manufacture and had sufficient heat treatment.

Also, the presence of low levels of total and coliform bacteria indicates little post-processing contamination, pointing to equally good processing and post-processing storage and handling of the product. These findings are in alignment with those that reveal the reduction and stable condition of microbes in oil-based products with less activity of water synthesized from nuts and seeds during the time of storage (Libby et al., 2021; Skendi et al., 2023; Osei et al., 2024).

Microbiological indicators such as total viable count, coliform count, and absence of pathogens play a vital role in determining the shelf life as well as the safety of spread products. When analyzed along with physicochemical indicators like free fatty acid, a complete assessment of the stability of products can be obtained. The values obtained on microbiological parameters presented in Table 6 indicate that the sesame-honey spread would be considered safe and could be stored for a long period. The results obtained inform the possibility of creating a shelf-stable sesame-honey spread.

As indicated in Table 6 and Figures 1 to 3, it is shown that with storage at 25°C, there was a gradual and constant rise in counts of microorganisms for the sesame and honey spread. The total aerobic count (TAC) rises from 2.1 × $10^1$ to 1.6 × $10^2$ cfu/g and the total coliform count (TCC) from 1.1 × $10^1$ to 7.5 × $10^1$ cfu/g, respectively. These show slow growth rates of microorganisms; however, these remain below safe global standards for fat-enriched and low-moisture-content spreads. Therefore, it can remain safe during storage. Mould growth occurs generally low until the end of week four, where it reaches its highest point, namely 1.6 × $10^1$ cfu/g at the end of week eight. Such slow growth and low levels of mould growth led to the

**Table 6: Shelf Life of Sesame–Honey Spread using Microbiological and Physicochemical Indicator** (Atingah, 2021).

| Test | Unit | Results | Specification |
|---|---|---|---|
| Total viable count | Cfu/g | < 30 | 1.0×$10^4$ |
| Total Coliform count | Cfu/g | < 10 | 1.0×$10^2$ |
| *E. coli* | Cfu/g | Not detected | 0.00 |
| *S. aureus* | Cfu/g | Not detected | 0.00 |
| *Salmonella typhi* | Cfu/g | Not detected | 0.00 |
| Yeast | Cfu/g | 0.00 | 1.0×$10^2$ |
| Molds | Cfu/g | 0.00 | 1.0×$10^1$ |

assumption that the conditions are not suitable for mould growth, which may be due to low water activity in the spreads together with the antimicrobial compounds present in honey. The antimicrobial compounds of honey are acknowledged to have a general inhibition on yeast and mould development. Similar findings have already been seen in spreads made from nuts and seeds, where water activity is the single most important factor restraining microbial growth outside refrigeration conditions (Libby et al., 2021; Skendi et al., 2023). Gradual changes in TAC and TCC values correspond to findings noted by Osei et al. (2024), wherein they indicated that acceptably low values of microbial counts are harmless if such growth occurs during a prolonged shelf life and minor post-processing exposures, provided that microbially stable oil-rich spread has very minor increases in counts. In this case, the honey-sesame paste can remain safe for consumption at room temperature for at least eight weeks. This means that the growth of bacteria and other microorganisms inside the paste must be very slow, indicating the naturalness and stability of the product as an edible item. It also highlights the importance of maintaining strict hygiene and minimizing post-manufacturing contamination of the product. Figure 1-3 shows the microbial growth of sesame-honey spread at Room Temperature.

## Shelf life of sesame–honey spread from a physicochemical perspective

Tracking FFA as an indicator of lipid deterioration and rancidity during storage, this study illustrates the way FFA increases over time under both 25°C and higher-temperature conditions. Table 7 and the graphs in Figure 4 indicate that FFA levels basically increase linearly to reflect triglyceride hydrolysis and oxidative reactions typical of such oil-rich foods as this spread. FFA increased from 0.12% at week 0 to 0.28% by week 8 at room temperature (25°C). The speed was just right and increasing very slowly, indicating gentle lipid degradation and good stability under normal storage conditions. The most probable reason for such a slow increase in peroxide values is the low water activity of the product, thus restricting hydrolysis, along with natural sesame oil antioxidants such as sesamol and sesamin, which significantly impede oxidation.

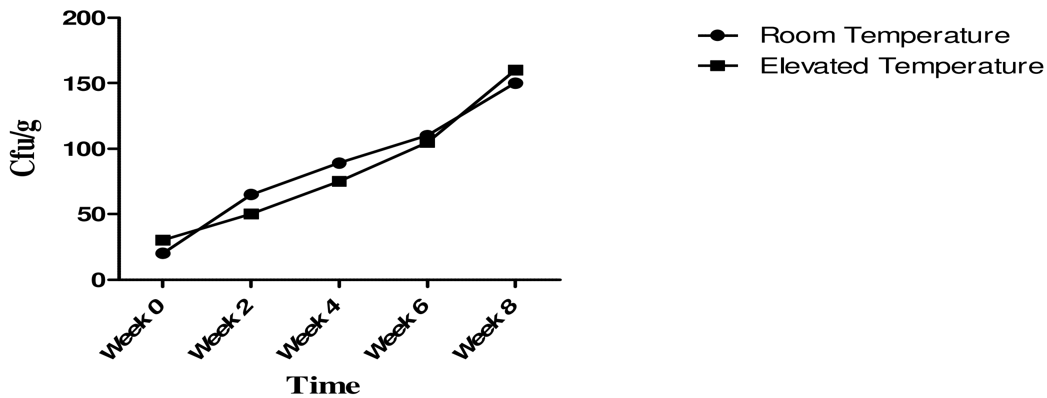


**Figure 1:** Total aerobic count of Sesame-honey spread over storage period.

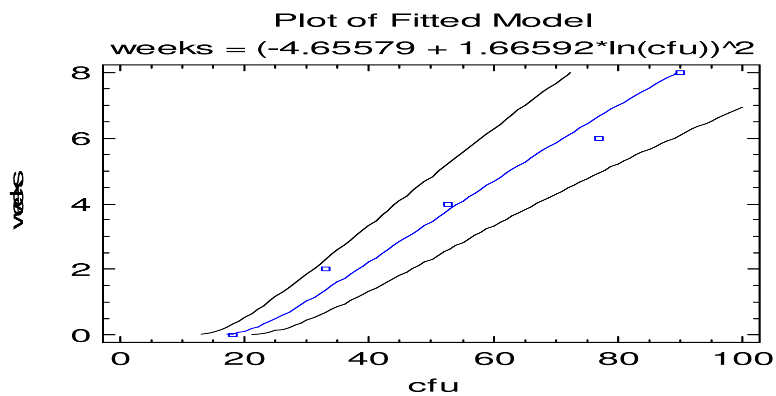


**Figure 2:** Shelf life of sesame spread using total aerobic count as predictor.

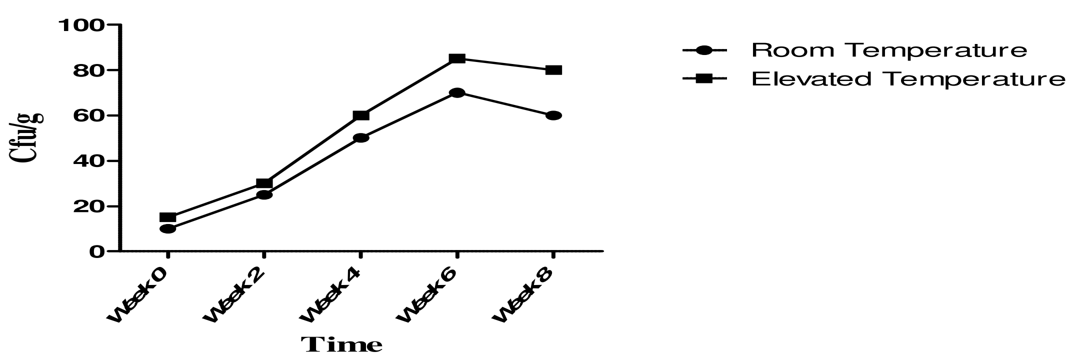


**Figure 3:** Total Coliform count of Sesame-honey spread over storage period

The FFA value remained higher when stored at higher temperatures and reached around 0.30% at week 8. It was thus expected that higher temperatures would increase the rate of chemical reactions that trigger the hydrolytic and oxidative damage of lipids, while greater accumulation of FFA under these conditions expresses the susceptibility of sesame oil lipids to heat-induced deterioration. Similar trends have been reported for other oil-based spreads and seed-derived products undergoing accelerated storage. Even with the upticks, FFA levels for both conditions

**Table 7:** Microbial loads of sesame-honey spread over time of storage (Atingah, 2021).

| Weeks | TAC | TCC | Mold |
|---|---|---|---|
| | **Room Temperature (25°C)** | | |
| Week 0 | $2.1\times10^1\pm1.41$ | $1.1\times10^1\pm0.71$ | 0.00 |
| Week 2 | $5.3\times10^1\pm4.24$ | $2.3\times10^1\pm2.83$ | 0.00 |
| Week 4 | $7.3\times10^1\pm2.83$ | $5.6\times10^1\pm5.66$ | $0.7\times10^1\pm3.53$ |
| Week 6 | $1.1\times10^2\pm4.95$ | $6.3\times10^1\pm3.54$ | $1.0\times10^1\pm4.24$ |
| Week 8 | $1.6\times10^2\pm8.49$ | $7.5\times10^1\pm4.24$ | $1.6\times10^1\pm8.49$ |
| | **Elevated Temperature (47°C)** | | |
| Week 2 | $6.9\times10^1\pm5.66$ | $3.3\times10^1\pm4.24$ | 0.00 |
| Week 4 | $8.4\times10^1\pm7.07$ | $5.2\times10^1\pm3.53$ | $1.1\times10^1\pm5.65$ |
| Week 6 | $1.2\times10^2\pm5.66$ | $7.7\times10^1\pm4.24$ | $1.6\times10^1\pm7.07$ |
| Week 8 | $1.7\times10^2\pm9.19$ | $9.0\times10^1\pm7.07$ | $2.1\times10^1\pm8.48$ |

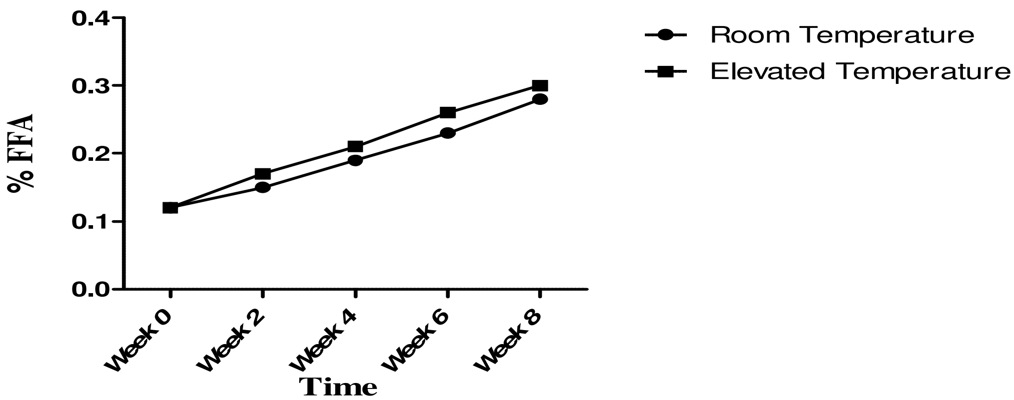


**Figure 4:** Free Fatty Acid content of sesame spread over storage period (Atingah, 2021).

remained within acceptable limits for edible oil-based products. This shows that the sesame honey spread maintained adequate lipid quality during the 8 weeks. FFA has proved to be a reliable marker for shelf-life physicochemical stability in assessing the quality of a product with time. In summary, the data indicates that the lipid stability is higher at room temperature than at higher temperatures. This indicates the importance of appropriate temperature treatment when storage of sesame-honey spread is under consideration and engenders this product as a potentially shelf-stable item.

**Sesame-honey spread shelf life: A combination of physico-chemical and microbiological approaches**

Figure 5 utilizes the concentration of Free Fatty Acid (FFA) as an indirect indicator regarding the shelf life of the sesame honey spread, as shown in Table 8. As it proceeds with storage, it becomes increasingly evident that the concentration of the free fatty acid increases under the conditions of room temperature or at high temperature. It is possible to note this from the data, which indicates that during the storage at ambient temperature, it would increase from 0.12% at week 0 to 0.28% at week 8, whereas, with the elevated temperatures, the increase would be slightly quicker instead to reach 0.30% in the same period. The slow rate of FFA production due to the temperature at room results in the fact that the lipid is more stable than the others: This observation agrees with earlier studies done by other researchers proving a similar speeding up of lipid decomposition with increasing temperatures (Frankel, 2005; Choe & Min, 2006), leading to enhanced hydrolysis and oxidation of lipids. From these observations, it can be postulated that Figure 5 indicates the utility of FFA in determining lipid storage life. Figure 6 emphasizes the performance of the distribution with respect to microbiological values, giving a combination of the overall shelf life based on microbiological predictors. The combined results of this study with the data for the FFA indicate that whereas physicochemical values undergo changes gradually, the microbial values remain within the safe limits. The consistency of the two indicates reliability regarding the determination of the shelf life. From the practical perspective, the integration of the FFA and microbial predictors provides a well-rounded evaluation regarding the shelf life. It can be safely concluded from the results that the sesame honey spread can be stored for an extended period of time, especially at room temperature. Furthermore, it stresses the need for the proper temperature regarding the storage of the sesame-honey spread, since higher temperatures will hasten the deterioration of the lipids, and though microbial safety is not a factor, the lipid deterioration would result in rancid flavours.

**Table 8:** Free Fatty Acid content of sesame spread oil over duration of storage (Atingah, 2021).

| Time | Room Temperature | Elevated Temperature |
|---|---|---|
| Week 0 | 0.12 | 0.12 |
| Week 2 | 0.15 | 0.17 |
| Week 4 | 0.19 | 0.21 |
| Week 6 | 0.23 | 0.26 |
| Week 8 | 0.28 | 0.30 |

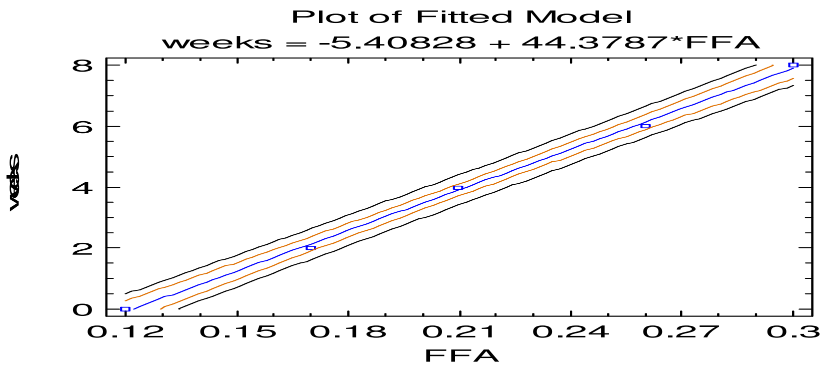


**Figure 5:** Shelf life of sesame spread using FFA as predictor (Atingah, 2021).

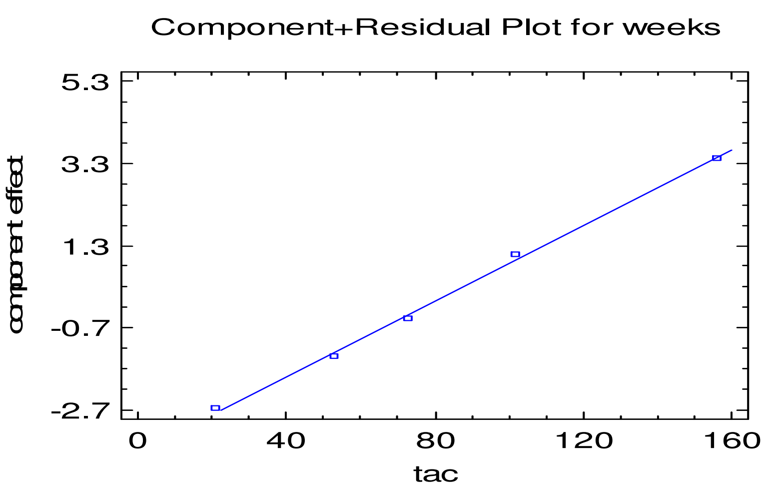


**Figure 6:** Overall shelf life determination using microbiological predictors (Atingah, 2021).

## Conclusion

The study assessed the impact of roasting time and ingredient optimization on the sesame-honey spread's nutritional quality, sensory characteristics, and storage stability. The results clearly indicate that processing conditions and formulation choices are decisive factors in the overall quality and acceptability of the product. The nutritional analysis showed that the increase in the proportion of sesame led to higher contents of fat and protein, thus confirming its status as an energy-dense and nutrient-rich food. On the contrary, the increase in the level of honey not only raised carbohydrate and moisture contents but also produced a sweeter and softer spread. The above-mentioned differences indicate that sesame honey spreads could be designed according to the varying nutritional needs and the different consumer preferences. Sensory evaluation indicated that all formulations were overall accepted as well, as all attributes had scores exceeding the acceptable limit. However, the composition containing 70% sesame and 30% honey (TT2) continued to exhibit top performance in the main sensory quality parameters such as aroma, smoothness, softness, and overall acceptability. Aroma and smoothness turned out to be the most important factors that determined consumer preference, thus pointing to the need for controlled roasting and oil release during processing. Shelf-life assessment using microbiological and physicochemical indicators confirmed that the sesame-honey spreads were safe for consumption throughout the 8-week storage period under both room and elevated temperatures. Microbial loads remained well below permissible limits, and no pathogenic organisms were detected. Free fatty acid levels showed a gradual rise during storage, especially at the higher temperatures but the corresponding values did not exceed the upper limit for good oxidative stability. The finding shows that an ideal sesame–honey spread can be reasonably priced, attractive for consumers, and safe from microbiological hazards. The outcome strongly supports the idea of transforming the locally processed sesame seeds into a high-quality, long-lasting food product. This product can be used not only in households but also for large-scale production in Ghana.

**REFERENCES**


Aboudou, K., Vodouhe-egueh, S., Aissi, M. V., & Soumanou, M. M. (2020). Optimization of roasting conditions for preservation of nutritional quality of terminalia catappa almonds by response surface methodology. *Journal of Food Studies*, *9*(1), 1-61.

Abughoush, M., Samhouri, M., Olaimat, A. N., Al-Holy, M. A., Aljanada, A., Al-Dabbas, M., & Asiri, S. A. (2025). *Development and fuzzy modeling of viscosity of new Halawa (Sesami) products. Applied Food Research, 5*(2), 101102. https://doi.org/10.1016/j.afres.2025.101102

Anyogu A, Somorin YM, Oladipo AO, Raheem S. (2024). Food safety issues associated with sesame seed value chains: Current status and future perspectives. *Heliyon.10*(16):e36347. doi: 10.1016/j.heliyon.2024.e36347. PMID: 39253262; PMCID: PMC11381738.

Atingah, C. A. (2021). *Quality characteristics of sesame seed spread* (Unpublished MPhil thesis, University of Education, Winneba, College of Technology Education, Kumasi). University of Education, Winneba. http://ir.uew.edu.gh

Chatterjee, P., & Tewari, S. (2024). *Sesame seeds as functional foods: An overview. International Journal of Horticulture and Food Science, 6*(2), 57–59. https://doi.org/10.33545/26631067.2024.v6.i2a.232

Dossa, K. F., Enete, A. A., Miassi, Y. E., & Omotayo, A. O. (2022). Economic analysis of sesame (Sesamum indicum L.) production in Northern Benin. *Frontiers in Sustainable Food Systems, 6*:1015122. https://doi.org/10.3389/fsufs.2022.1015122

Dossou, S. S. K., Luo, Z., Deng, Q., Zhou, R., Zhang, Y., Li, D., Li, H., Tozo, K., You, J., & Wang, L. (2024). Biochemical and molecular insights into variation in sesame seed antioxidant capability as revealed by metabolomics and transcriptomics analysis. *Antioxidants, 13*(5), 514. https://doi.org/10.3390/antiox13050514

Gazali, B. T. A., Sanni, V., & Ahanchede, A. (2022). Farmers' knowledge, practices and use of sesame genetic resources in the production systems of Benin: Case study of agro-ecological zone IV. *Heliyon, 8*(12), e11870. https://doi.org/10.1016/j.heliyon.2022.e11870

Hou, L.-X., Li, C.-C., & Wang, X.-D (2018). Physicochemical, Rheological and Sensory Properties of Different Brands of Sesame Pastes. *Journal of Oleo Science* 11;*67*(10):1291-1298. doi: 10.5650/jos.ess18109. Epub 2018 Sep 13. PMID: 30210080.

Jin, L., Zhao, X.-J., Zhao, Y., Gao, S.-A., Liu, H.-M., Ma, Y.-X., Wang, X.-D., & Hou, L.-X. (2022). Physicochemical properties of the sesame paste produced by a novel process technology—ball milling. *International Journal of Food Science and Technology, 57*(11), 7254–7266. https://doi.org/10.1111/ijfs.16074

Kusse K, Ermias G, Darcho D (2022) Value Chain Analysis of Sesame (Sesame Indicum) in South Omo Zone, Southern Ethiopia. *J Agri Sci Food Res. 13*:501.

Libby O. Onyeka, Abiodun A. Adesiyun, Karen H. Keddy, Ayanda Manqele, Evelyn Madoroba & Peter N. Thompson. (2021). Prevalence, risk factors and molecular characteristics of Shiga toxin-producing *Escherichia coli* in beef abattoirs in Gauteng, South Africa. *Food Control, 123*, 107746. https://doi.org/10.1016/j.foodcont.2020.107746

Mahajan, A., Roy, V., & Sharma, P. (2025). Unraveling the biochemical composition and potential applications of sesame seeds and seed cake: A decade overview. *Oil Crop Science, 10*(2), 144–153. https://doi.org/10.1016/j.ocsci.2025.04.005

Mijena, R. B. (2017). Optimization of sesame roasting parameters and level of ingredients for sesame fat spread production. International Journal of Nutrition and Food Sciences, 6(4), 149–157. https://doi.org/10.11648/j.ijnfs.20170604.11

Mohammed Sdiq, S. J., Omer, Z. O., Salih, A. M., Ali, R. A., Mahmood, A. A., Sirwan, K., & Hameed, K. (2025). Comparative analysis of physicochemical and sensory properties of local sesame tahini. *European Journal of Nutrition & Food Safety, 17*(5), 74–83. https://doi.org/10.9734/ejnfs/2025/v17i51709

Montgomery, D. C. (2020). *Design and analysis of experiments* (10th ed.). John Wiley & Sons.

Mulate Z., & Hayelom B. (2020). Comparative Assessment of Some Physicochemical Properties of Different Sesame Varieties and Oil Yield, Ethiopia. *Bioprocess Engineering, 4*(1), 23-28. https://doi.org/10.11648/j.be.20200401.14

Muthoni, J., & Shimelis, H. (2025). Production of minor tropical oil crops in Africa: Case of sesame (Sesamum indicum L.). *Australian Journal of Crop Science, 19*(07), 816–829. https://doi.org/10.21475/ajcs.25.19.07.p357

Oboulbiga E.B, Douamba Z, Compaoré-Sérémé D, Semporé J.N, Dabo R, Semde Z, Tapsoba F.W-B, Hama-Ba F., Songré-Ouattara L.T, Parkouda C. & Dicko MH (2023). Physicochemical, potential nutritional, antioxidant and health properties of sesame seed oil: a review. *Front. Nutr. 10*:1127926. doi: 10.3389/fnut.2023.112792

Okwunakwe, A. F., Anhwange, B. A., Adie, P. A., & Ariahu, C. C. (2025). Sensory and Quality Evaluation of Sesame (Sesamum indicum) Seed-Based Salad Cream. Sahel *Journal of Life Sciences FUDMA, 3*(1), 207–216. https://doi.org/10.33003/sajols-2025-0301-25

Osei, C. Y., Lee, S., Lee, G.-A., Lee, S. H., Yoo, E., Lee, J.-E., Kim, E.-G., & Yang, T.-J. (2024). *Evaluation of agronomic traits, total phenolic content, and antioxidant properties of sesame seeds of different colors and origin. Foods, 13*(18), 2932. https://doi.org/10.3390/foods13182932

Özcan, M. M., Uslu, N., & Dursun, N. (2023). The effect of sesame seed processing steps on bioactive properties, nutraceutics and mineral contents of sesame seed, sesame paste (tehina) and oils. *Food and Humanity, 1*, 710–715. https://doi.org/10.1016/j.foohum.2023.07.013

Resurreccion, A. V. A. (2018). Consumer sensory testing for product development. Springer.

Sanni G.B.T.A, Ezin V., Ahanchede A. (2022). Farmers' knowledge, practices and use of sesame genetic resources in the production systems of Benin: case study of agro-ecological zone IV. *Heliyon 8*(12):e11870. doi: 10.1016/j.heliyon.2022.e11870. PMID: 36466569; PMCID: PMC9712128.

Seid F. & Mehari B. (2022). Elemental and Proximate Compositions of Sesame Seeds and the Underlying Soil from Tsegede, *Ethiopia. Int J Anal Chem.* Dec *29*;2022:1083196. doi: 10.1155/2022/1083196. PMID: 36618770; PMCID: PMC9815929.

Sintim, H. O. (2024). Seed quality and relative lignan profiles of sesame prospected from northern Ghana. *Heliyon, 10*(20), e39108. https://doi.org/10.1016/j.heliyon.2024.e39108

Skendi, A., Bouloumpasi, E., Chatzopoulou, P., Biliaderis, C. G., & Irakli, M. (2023). Comparison of drying methods for the retention of phenolic antioxidants in post-distillation solid residues of aromatic plants. *LWT, 189*, 115463. https://doi.org/10.1016/j.lwt.2023.115463

Song, G., Wang, J., He, Y., Sun, Y., & Deng, Z. (2025). *Roasting increases the oil yield of sesame seeds by altering the amino acid composition and secondary structure of the sesame protein. Food Bioscience, 68*, 106491. https://doi.org/10.1016/j.fbio.2025.106491.

Wang, R., Wu, L.-X., Guo, B.-X., Zhao, P.-H., Yin, W.-T., Liu, H.-M., Mei, H.-X., & Duan, Y.-H. (2024). *Characterization of aroma-active compounds in sesame hulls at different roasting temperatures by SAFE and GC-O-MS. Food Chemistry: X, 21*, 101203. https://doi.org/10.1016/j.fochx.2024.101203

Wei P, Zhao F, Wang Z, Wang Q, Chai X, Hou G, Meng Q. (2022). Sesame (Sesamum indicum L.): A Comprehensive Review of Nutritional Value, Phytochemical Composition, Health Benefits, Development of Food, and Industrial Applications. *Nutrients. 14*(19):4079. doi: 10.3390/nu14194079. PMID: 36235731; PMCID: PMC9573514.

Yin, W., Washington, M., Ma, X., Yang, X., Lu, A., Shi, R., Zhao, R., & Wang, X. (2020). *Consumer acceptability and sensory profiling of sesame oils obtained from different processes. Grain & Oil Science and Technology, 3*(2), 39–48. https://doi.org/10.1016/j.gaost.2020.04.001.