ORIGINAL ARTICLE

Development and Evaluation of Guar Gum-Based Mayonnaise in Combination with Pumpkin and Sesame Seed Oil Blends

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ABSTRACT

Pumpkin seeds generally considered as agro-industrial waste, are useful source of unsaturated fatty acids that are lacking in modern diets. The research was conducted to characterize pumpkin and sesame seed oil and to evaluate their impact on oxidative stability and sensory attributes of mayonnaise. The pumpkin and sesame seed oils were extracted using solvents' extraction technique. After extraction, the oils were subjected to analyze different physicochemical characteristics. Fatty acid profile using GC-FID demonstrated that unsaturated fatty acids were in higher concentration as compared to saturated fatty acids. After the oil analysis, it was utilized in the development of mayonnaise. To check the overall quality of mayonnaise the physicochemical analysis, antioxidant activity analysis, and sensory evaluation were performed during the storage period of 0, 15, 30, 45, and 60 days. Antioxidant potential decreased with storage and highest potential was observed for T5 at end and was higher than the control treatments. In both DPPH and FRAP, treatment T5 (containing 100% of sesame seed oil) showed better results. According to sensory parameters, sesame seed oil is excellent at preventing oxidation in mayonnaise but was not proven to be favorable for sensory perception.

Keywords: Pumpkin Seed Oil, Sesame Seed Oil, Agro-Industrial Waste, Guar Gum, Mayonnaise.

1. INTRODUCTION

Vegetable oils have become one of the global topics of discussion due to several factors including increased awareness of health risks associated with trans fatty acids, rising consumer demand for natural products, and rising worldwide demand for vegetable oils (U.S. FDA, 2013). Regardless of the large variety of vegetable oil sources available soybean, palm, rapeseed, and sunflower oil account for 31.6, 30.5, 15.5, and 8.6 million tons of global consumption, respectively. Traditional vegetable oil sources are no longer able to supply the growing demands of the industrial and domestic sectors. As a result, the need of the hour is to seek for new sources to fulfil ever-increasing consumer demand. Non-conventional oil seeds are a major source of concern in addressing this problem (Gohari *et al*., 2011).

Pumpkin as a member of the family Cucurbitaceae belongs to the genus Cucurbita which is one of the world's most popular vegetable. *Cucurbita moschata, Cucurbita pepo,* and *Cucurbita maxima* are the three most common pumpkin species found globally. The oil content of pumpkin seeds ranges from 30 to 50% (Amin *et al*., 2019). Even though pumpkin seed oil has properties that are suitable for industrial usage and can contribute to healthier human diets (Stevenson *et al*., 2007).

Sesame oil is derived from the oleaginous plant *Sesamum indicum* L. which is a member of family Pedaliaceae. The Pedaliaceae family includes plants that can be cultivated in both tropical and temperate climates. Sesame is referred to as an orphan crop because it has received little scientific attention and no research institute has designated it as a crop. It is the most significant and earliest crop of oil seeds due to high-quality seed oil it produces. Most of the sesame is cultivated in Africa and Asia (Mujtaba *et al*., 2020).

Sesame seeds have higher contents of oil approximately 50% and higher oxidative stability. Sesame seed oil on the other hand contains a unique class of compounds identified as lignans which are comprised of natural antioxidants including sesamin, sesamolin, and a small percentage of sesamol, making it highly resistant to oxidation (Chetana *et al*., 2019; Zhou *et al*., 2020).

Mayonnaise is a frequently consumed culinary product that has been steadily gaining in popularity over the last several years. In recent years, there has been a tremendous increase in demand for low-fat and eggless mayonnaise due to consumer concerns regarding cholesterol levels and high-fat diets (Chetana *et al*., 2019). Guar gum and xanthan gum are two of the most widely investigated fat substitutes. The texture, color, flavor, stability, storage life, and creaminess of the emulsified product are all influenced by the fat contents that make up 70 to 80% of the product (Amin *et al*., 2014).

These growing health-related concerns, rising consumers demand for safe and natural products, and the toxicity of the synthetic antioxidants have diverted our attention in the development of mayonnaise using sesame and pumpkin seed oil as sesame and pumpkin seed oil have a hypocholesterolemic effect and contains more natural and safer antioxidants. The objectives of this research were to characterize pumpkin and sesame seeds in terms of their oil content and quality and determining the impact of pumpkin and sesame seed oil blends on oxidative stability and sensory attributes of mayonnaise.

2. MATERIALS AND METHODS

2.1. Procurement of Raw Materials

Raw materials including seeds of pumpkin and sesame with guar gum and all the other ingredients were purchased from the local market of Faisalabad. All chemicals were analytical-grade and were acquired from Sigma-Aldrich Chemicals Co. Pakistan.

2.2. Extraction of Pumpkin and Sesame Seed Oil

At first, the seeds were cleaned and washed with clean running water in order to remove sand and other foreign materials. After washing, seeds were dried in an oven at 105°C for a period of 24h or till constant weight. Then the seeds were crushed to fineness by using a grinder and converted into powder form. The fat content of pumpkin and sesame seeds were collected using the Soxhlet extraction method, which is described by AOCS (2017) official method Am 2-93.

2.3. Physicochemical Analysis of Pumpkin and Sesame Seed Oil.

Free fatty acid

Free fatty acids of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Ca 5a-40. Weighed 14.1±0.2g of sample in Erlenmeyer flask. Then 25ml of hot neutral alcohol (ethyl alcohol 95%) was added. Few drops of phenolphthalein indicator were added and titrated against 0.1M NaOH solution depending on fatty acid content.

$$\% \text{ FFA} = \frac{\text{ml of alkali} \times \text{M} \times 28.2}{\text{sample weight(g)}}$$

where;

M = molarity

Peroxide value

Peroxide value of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Cd 8-53.

Peroxide value as milliequivalents peroxide per 1000g sample =

$$\frac{\text{(S-B)(N)(1000)}}{\text{sample weight(g)}}$$

where;

N = normality of $Na_2S_2O_3$ solution

B = volume of blank titration

S = volume of sample titration

Iodine value

The iodine value of pumpkin and sesame seed oil was determined by following AOCS (2017) official methodTg1a-64.

$$\text{Iodine value} = \frac{\text{(B-S)} \times \text{N} \times 12.69}{\text{sample weight(g)}}$$

where;

N = normality of $Na_2S_2O_3$ solution

B = volume of blank titrant (ml)

S= volume of sample titrant (ml)

Specific gravity

The specific gravity of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Cc 10b-25.

$$\text{Specific gravity of oil at 30ºC} = \frac{\text{A-B}}{\text{C-B}}$$

where;

A =weight in grams of pycnometer with oil at 30°C

B = weight in grams of pycnometer at 30°C

C = weight in grams of pycnometer with water at 30°C

Saponification value

The saponification values of pumpkin and sesame seed oil were measured by following the AOCS (2017) official method Cd 3a-94.

$$\text{Saponification value} = \frac{\text{(B-S)} \times \text{N} \times 56.1}{\text{sample weight(g)}}$$

where;

N = normality of HCl solution

B = volume of blank titrant (ml)

S= volume of sample titrant (ml)

Acid value

The acid value of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Aa 6-38.

$$\text{Acid value} = \frac{\text{ml} \times \text{N} \times 56.1}{\text{sample weight(g)}}$$

where;

N= normality of NaOH solution

ml = ml of NaOH required

56.1 = molecular weight (or equivalent weight) of KOH

Acid value = mg KOH required to neutralize acid in 1g of oil

Refractive index

The refractive index of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Cc 7-25.

Smoke point

The smoke point of pumpkin and sesame seed oil was determined by following AOCS (2017) official method Cc 9a-48.

2.4. Fatty Acid Profile by GC-FID

Fatty acid profile of pumpkin and sesame seed oil was analyzed by the method explained by Ivanova-Petropulos *et al*. (2015). Fatty acids were expressed as the concentration percentage. Trans-esterification and analysis were performed on both oil samples.

2.5. Development of Mayonnaise

The mayonnaise was prepared by following the method of Chetana *et al*. (2019). Different mayonnaise treatments were prepared including two control treatments $T_0^*$and T_0 containing egg yolk and guar gum, and mayonnaises containing different ratio of pumpkin and sesame seed oil (100:0, 75:25, 50:50, 25:75, 0:100), respectively. The control treatment was made with refined sunflower oil (70%), egg yolk (19.10%), vinegar (7.20%), mustard (1.80%), salt (1.00%), sugar (0.60%), and white pepper (0.30%). According to the experimental design in pumpkin seed oil, sesame seed oil, and blends of both pumpkin and sesame seed oil were used to develop mayonnaise. The mayonnaises were packed in plastic cups and kept at 15±1ºC. At 0, 15, 30, 45, and 60days, samples were taken and carried to the room temperature (27±1ºC) for the further analysis.

2.6. Product Analysis

pH

The pH of mayonnaise samples was determined by following AOAC (2019) official method 981.12.

Viscosity

The viscosity of mayonnaise samples was determined by following AOCS (2017) official method Ja10-87 using Brookfield dial reading viscometer. When making a viscosity measurement, the reading should be noted and multiplied by the factor appropriate to the viscometer model/spindle/speed combination being used.

$$\text{Viscosity} = \text{Viscometer reading} \times \text{Brookfield conversion factor}$$

2.7. Extraction of Lipid Phase from Mayonnaise

The lipid phase in all the mayonnaise samples was collected according to the method defined by Shabbir *et al*. (2015).

2.8. Analysis of Lipid Phase Extracted from Mayonnaise

Free fatty acids

Free fatty acids of the lipid phases separated from the mayonnaise samples were determined by following AOCS (2017) Ca 5a-40 official method. Weigh 14.1±0.2g of sample in Erlenmeyer flask. Then 25 ml of hot neutral alcohol (ethyl alcohol 95%) was added. Few drops of phenolphthalein indicator were added and titrated against 0.1MNaOH solution depending on fatty acid content.

$$\%\ FFA = \frac{\text{ml of alkali} \times M \times 28.2}{\text{sample weight(g)}}$$

where;

M = molarity

Iodine value

The iodine value of the samples was determined by following AOCS (2017) official method Tg 1a-64. One blank reading with each sample was also conducted.

$$\text{Iodine value} = \frac{(B-S) \times N \times 12.69}{\text{sample weight(g)}}$$

where;

N = normality of $Na_2S_2O_3$ solution

B = volume of blank titrant (ml)

S = volume of sample titrant (ml)

Antioxidant activity analysis

DPPH radical scavenging assay

The DPPH radical scavenging assay was performed according to Sun and Ho (2005) method.

Ferric reducing antioxidant power (FRAP) assay

The ferric reducing antioxidant power (FRAP) assay was performed by following the methodology of Shabbir *et al*. (2015).

2.9. Sensory Analysis

Ten members of the National Institute of Food Science and Technology had subjected mayonnaise samples prepared using pumpkin and sesame oil at varying concentrations to meaning assessments. Each sensory feature color, taste, mouth feel, and overall acceptability was asked to be evaluated with the control treatment as the basis for evaluation. For the evaluation of sensory attributes, a 9-point hedonic scale was used as defined by Meilgaard *et al*. (2016).

2.10. Statistical Analysis

The collected data was statistically analyzed to find the level of significance by utilizing the analysis of variance under 2-way factorial design as reported by Montgomery (2017).

3. RESULTS

3.1. Free Fatty Acids

The free fatty acids of pumpkin seed oil found in this study are 2.05±0.10% as mention in Table **1**.

3.2. Peroxide Value

The peroxide value of pumpkin seed oil found in this study is 1.46±0.07 (meq O_2/kg of oil) that is comparable to findings by Khairat *et al*. (2019) who reported peroxide value as 1.32±0.02 (meq O_2/kg of oil). The peroxides value of sesame seed oil was recorded as 2.24±0.11 (meq O_2/kg of oil) (Table **1**).

3.3. Iodine Value

In this research the iodine value of pumpkin seed oil found is 103.34±2.06(g I_2/100g of oil). In this research the physicochemical analysis of pumpkin seed oil was done. The iodine value of sesame seed oil is 110.89±2.22(g I_2/100g of oil) (Table **1**).

3.4. Specific Gravity

The specific gravity of pumpkin seed oil found was 0.891±0.018 while the specific gravity of sesame seed oil was 0.910±0.027 (Table **1**).

3.5. Saponification Value

The results of saponification value of pumpkin seed oil are 171.01±3.42(mg KOH/g of oil however, the saponification value of sesame seed oil found was 180.13±3.60(mg KOH/g of oil) (Table **1**).

3.6. Acid Value

The acid value of pumpkin seed oil determined was 4.08±0.20(mg KOH/g of oil). The acid value of sesame seed oil found was 1.15±0.06 (mg KOH/g of oil). The lower acid indicates the oil edibility and its suitability for industrial applications (Table **1**).

3.7. Refractive Index

The refractive index 1.4635±0.0146 of pumpkin seed oil found is comparable to the findings by Mathangi (2018) who recorded the refractive index value of 1.47. The refractive index of sesame seed oil is 1.4710±0.0157 (Table **1**).

3.8. Smoke Point

In comparison to the smoke point of pumpkin seed oil (135.00±2.70ºC) sesame seed oil has been shown to have a higher smoke point (208.00±4.16ºC). Consequently, sesame seed oil burned at a greater temperature than pumpkin seed oil making it ideal for industrial applications (Table **1**).

3.9. Fatty Acid Profile by GC-FID Of Pumpkin and Sesame Seed Oil

Four of the total seven fatty acids were unsaturated. The fatty acids including oleic acid (59.7%), palmitic acid (18.50%), stearic acid (2.3%), and linoleic acid (1.90%) were the most abundant. The gas chromatography profile of pumpkin seed oil is given in Fig **1**. The fatty acid profile of sesame seed oil which can be used to assess the nutritional value and stability of oil is presented in Table **2**. UFAs were the dominant fatty acids in sesame seed oil as well. The fatty acids including oleic acid (60.8%), palmitic acid (19.50%), and linoleic acid (2.8%) were the most abundant (Table **2**). In sesame seed oil the total concentration of UFAs was approximately 67.3% and contained around 19.9% of saturated fatty acids. The gas chromatography profile of sesame seed oil is shown in Fig **1**.

3.10. Physicochemical Analysis of Mayonnaise

pH

The results of the statistical analysis of variance indicated that the treatments, storage period, and their interaction all had a highly significant impact on the pH of all the treatments.

The mean values show the effect of different treatments on the pH of mayonnaise during 60 days of storage study. With increasing storage days, the pH decreased in all the samples. There is a significant difference in the pH values of all the treatments at day 0^{th}. At day 60^{th}, all treatments had reached their lowest values, however the control treatment T_0^* showed the lowest mean value (3.95) because of oxidative and hydrolytic enzymes activity that could possibly be found in the eggs. As the percentage of sesame seed oil was increased the pH of the treatment's increases. However, the control treatment T_0showed the highest mean values (4.72) in which the guar gum was used. The results of T_3 and T_4 are comparable to the control treatment T_0. The oil type and its chemical composition significantly influence the pH of the mayonnaise.

Viscosity

The mean values show the effect of different treatments on the viscosity of mayonnaise during 60 days of storage study. With increasing storage days, the viscosity decreased in all the samples. There is a significant difference in the viscosity of all the treatments at day 0^{th}. At day 60^{th}, all treatments had reached their lowest values, however the control treatment T_0^* and pumpkin seed oil treatment T_1 showed the lowest mean values of 43. 61Pa.s and 43.20Pa.s. As the percentage of sesame seed oil was increased the viscosity of the treatment's increases as compared to the pumpkin seed oil treatments. However, the control treatment T_0 showed the highest mean value (50.86Pa.s) in which the guar gum was used. The treatment T_5 also showed good results (48.01Pa.s) that are comparable to control treatment T_0.

3.11. Analysis of Lipid Phase Extracted from Mayonnaise

Free fatty acids

The results of statistical analysis of variance indicated that the treatments, storage period, and their interaction all had a highly significant impact on the levels of free fatty acids in all the treatments.

T_1 had the highest free fatty acid concentration (2.47%) on 0^{th} day as reported in Table **3**. With increasing storage days, the FFA percentage increased in all the samples. At 60^{th} day, all treatments had reached their maximum levels, however the treatment T_1showed the highest value (4.09%). Despite that the free fatty acid concentration increased with storage, free fatty acids growth was minimal in sesame seed oil treatments. As the percentage of sesame seed oil was increased the contents of free fatty acids decreased. T_5 had the lowest mean values (1.40%), which were lower than the control treatments T_0 (1.54%) and T_0^* (1.57%).

Iodine value

The results of statistical analysis of variance indicated that the treatments, storage period, and their interaction all had a highly significant impact on the iodine value in all treatments.

T_1 had the lowest iodine value (103.74gI_2/100g of oil) on 0^{th} day as reported in Table **3**. With increasing storage days, the iodine value decreased in all the samples. At day 60^{th}, all treatments had reached their lowest values, however, the control treatment T_0^* showed the lowest value (57.63gI_2/100g of oil). Despite that the iodine value decreased with storage, this reduction was minimal in sesame seed oil treatments. As the percentage of sesame seed oil increased the decrease in iodine value slows down. T_5 showed the highest mean values (99.23gI_2/100g of oil) having the maximum unsaturation which were higher than the control treatments T_0 (90.46gI_2/100g of oil) and T_0^*(82.96gI_2/100g of oil).

3.12. Antioxidant Activity Analysis

DPPH radical scavenging assay

At day 0th the highest DPPH values in all the treatments were reported as shown in Table **3**. The control treatment containing sunflower seed oil and eggs showed the lowest value (37.15%) at day 0th as it didn't contain any antioxidants. As the percentage of sesame seed oil was increased the % DPPH inhibition also increases. The treatments containing pumpkin seed oil and their blends also shows good DPPH free radical scavenging activity. However, it was highest in the treatment T_5 (61.76%) at day 0th as it contains more natural antioxidants. With increasing storage days, the DPPH inhibition percentage decreased in all the samples. At day 60th, all treatments had reached their minimum values. At the end of storage period, the highest mean values were observed in treatments T_5 (47.34%) and T_4 (47.36%), and the lowest mean value was observed in control sample T_0^* (24.55%). Sesame seed oil contains antioxidant components that are excellent at scavenging free hydroxyl ions delaying the oxidation of mayonnaise.

Ferric reducing antioxidant power (FRAP) assay

The results of statistical analysis of variance indicated that the treatments and storage period had a highly significant, however their interaction had a significant impact on the FRAP value in all the treatments.

At day 0th the highest FRAP values in all the treatments were reported as shown in Table **3**. The control treatment containing sunflower seed oil and eggs showed the lowest value (39.95 µmolTE/mL) at day 0thas it didn't contain any antioxidants. As the percentage of sesame seed oil was increased the FRAP values also increases. The treatments containing pumpkin seed oil and their blends also showed good ferric reducing power. However, it was highest in the treatment T_5 (68.44µmolTE/mL) at day 0th as it contains more natural antioxidants. With increasing storage days, the FRAP values decreased in all the samples. At day 60th, all treatments had reached their minimum values. The highest mean values were observed in treatment T_5 (55.12µmolTE/mL), and the lowest mean value was found in control sample T_0^* (27.67µmolTE/mL). Sesame seed oil contains antioxidant components that are excellent at scavenging the ferrous ions delaying the oxidation of mayonnaise.

3.13. Sensory Analysis

The findings revealed that storage period and treatments have a highly significant impact on color, taste, mouthfeel, and overall acceptability however, they are not affected by the interaction between treatments and storage periods and remain non-significant. The first and most powerful sensory impression is color. The color of the mayonnaise ranges from almost white to light yellow. All of the mayonnaise treatments were white to yellow in color and had a shiny and smooth appearance. Because of the egg yolks the color of the control treatment was yellow, but mayonnaise prepared with guar gum was white in color. However, the addition of pumpkin and sesame seed oils and their blends slightly changed the color from cream to light yellow. These treatments resembled the mayonnaise sold commercially. Fig **2** indicates that the treatments T_1 received the highest scores from the panelists at day 0th, whereas the treatments T_0^*, and T_2 received the lowest score. At the end of storage period all of the treatments received lower scores.

Fig **2** indicates that the treatment T_0^* and T_0 received the highest score from the panelists at day 0th. T_5 received the lowest score of on day 0th out of all the treatments.

However, the treatments containing pumpkin and sesame seed oil and their blends showed the lowest mean scores. At the end of storage period all of the treatments received lower scores in overall acceptability. These results revealed that as the percentage of sesame seed oil increases it badly effects the overall acceptability of mayonnaise. Also, the decline in overall acceptability with storage is attributable to unfavorable changes in the mayonnaise taste, color, and mouthfeel.

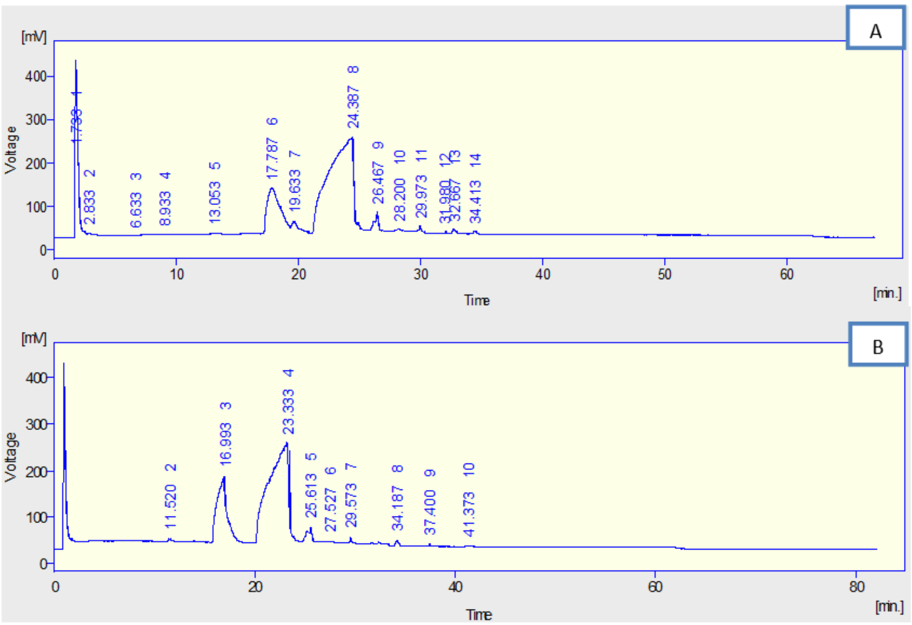

Figure 1. Gas chromatography profile (A) pumpkin seed oil (B) Sesame seed oil

Table 1. Physicochemical Characteristics of Pumpkin and Sesame Seed Oil

Physicochemical Characteristic	Pumpkin Seed Oil Mean ± S.D	Sesame Seed Oil Mean ± S.D
Free fatty acids (%)	2.05±0.10	0.58±0.03
Peroxide value (mEq O_2/kg of oil)	1.46±0.07	2.24±0.11
Iodine value (gI_2/100g of oil)	103.34±2.06	110.89±2.22
Specific gravity	0.891±0.018	0.910±0.027
Saponification value (mg KOH/g of oil)	171.01±3.42	180.13±3.60
Acid value (mg KOH/g of oil)	4.08±0.20	1.15±0.06
Refractive Index	1.4635±0.0146	1.4710±0.0157
Smoke point (ºC)	135.00±2.70	208.00±4.16

Table 2. Fatty Acid Profile of Pumpkin and Sesame Seed Oil

	Fatty Acid	Retention time	Peak area (%)
Pumpkin seed oil	Solvent (methanol)	1.733	13.5
	Pentadecane (Internal Std)	2.833	0.8
	Cis-10 pentadecanoic acid (C15:1)	8.933	0.6
	Palmitic acid (C16:0)	17.787	18.5
	Stearic acid (C18:0)	19.633	2.7
	Cis-9-oleic acid (C18:1)	24.387	59.7
	Linolenic acid (C18:3)	28.200	1.6
	Linoleic acid (C18:2)	29.973	1.9
	Arachidic acid (C20:0)	31.980	0.7
Sesame seed oil	Solvent (methanol)	0.953	11.9
	Myristicacid(C14:0)	11.520	0.6
	Palmitic acid (C16:0)	16.993	19.7
	Cis-9-oleic acid (C18:1)	23.333	60.8
	Linoleic acid (C18:2)	25.613	2.9
	Linolenic acid (C18:3)	27.527	1.7
	Cis-11,14-eicosadienoic acid (C20:2)	29.573	2.4

Table 3. Mean Values Showing the Effect of Different Treatments on the Different Quality Parameters of Mayonnaise During 60 Days of Storage Study

Treatments	Storage (Days)	pH	Viscosity (Pa.s)	FFA (%)	Iodine Value (gI_2/ 100g of oil)	DPPH (%)	FRAP (µmolTE/mL)
T_0^*	0	4.37±0.11^{jk}	45.11±0.20^{p}	0.34±0.04^{t}	129.04±2.27^{a}	37.15±1.10^{fghi}	39.95±0.74^{lm}
	15	4.07±0.04^{o}	44.25±0.33^{q}	0.70±0.03^{rs}	102.76±3.08^{fgh}	29.42±0.52^{klm}	35.96±1.37^{op}
	30	3.98±0.08^{pq}	43.49±0.15^{r}	1.23±0.09^{pq}	65.74±3.16^{w}	23.60±1.50^{nop}	27.53±1.34^{rs}
	45	3.76±0.14^{s}	42.73±0.43^{s}	1.98±0.11^{kl}	59.65±3.69^{x}	18.27±1.46^{pq}	19.41±1.50^{t}
	60	3.59±0.03^{t}	42.45±0.25^{s}	3.58±0.06^{c}	57.63±2.98^{x}	14.32±1.54^{q}	15.50±1.76^{u}
T_0	0	5.12±0.02^{a}	53.15±0.11^{ab}	0.42±0.02^{t}	130.41±3.15^{a}	40.46±1.34^{efgh}	45.55±1.20^{j}
	15	4.98±0.13^{b}	52.08±0.19^{efg}	0.87±0.05^{r}	108.25±3.12^{cde}	37.34±1.58^{fghi}	41.74±0.59^{kl}
	30	4.73±0.12^{ef}	51.22±0.31^{h}	1.53±0.08^{o}	85.01±1.60^{nop}	36.63±0.59^{ghi}	35.48±1.68^{op}
	45	4.46±0.08^{hi}	49.34±0.25^{i}	2.04±0.05^{k}	67.86±3.10^{vw}	30.24±1.25^{jklm}	25.39±0.86^{s}
	60	4.32±0.05^{kl}	48.53±0.20^{kl}	2.86±0.10^{ef}	60.78±3.06^{x}	20.32±0.72^{op}	21.21±1.41^{t}
T_1	0	4.39±0.10^{ijk}	44.66±0.19^{h}	2.47±0.10^{ghi}	103.74±2.53^{efg}	56.68±0.94^{ab}	58.65±1.91^{ef}
	15	4.23±0.13^{mn}	44.05±0.10^{i}	2.62±0.10^{g}	98.07±1.97^{ij}	45.79±0.72^{de}	56.59±1.80^{fg}
	30	4.09±0.06^{o}	43.42±0.17^{k}	2.92±0.07^{ef}	89.51±3.19^{lmn}	40.60±0.34^{efgh}	46.34±0.76^{j}
	45	3.93±0.12^{qr}	42.54±0.39^{mn}	3.53±0.08c	79.33±1.72^{qrs}	34.25±1.60^{ijk}	39.29±1.19^{lmn}
	60	3.78±0.10^{s}	41.34±0.47^{o}	4.09±0.12^{a}	70.44±2.01^{v}	22.30±1.05^{op}	28.41±1.85^{r}
T_2	0	4.49±0.03^{gh}	45.98±0.21^{cde}	1.92±0.08^{klm}	108.71±1.96^{cd}	56.75±1.55^{ab}	60.47±0.94^{cde}
	15	4.46±0.05^{hi}	44.82±0.16^{gh}	2.03±0.04^{k}	99.49±3.43^{ghij}	50.36±1.61^{cd}	57.65±1.79^{ef}
	30	4.26±0.10^{lm}	44.13±0.08^{i}	2.58±0.09^{gh}	92.28±2.48^{kl}	42.44±1.21^{ef}	50.44±1.92^{i}
	45	4.03±0.02^{op}	43.62±0.24^{jk}	3.22±0.05^{d}	80.67±2.66^{pqr}	35.46±0.65^{hij}	41.26±0.70^{kl}
	60	3.88±0.09^{r}	42.36±0.12^{n}	3.88±0.06^{b}	73.60±2.96^{tu}	25.43±1.57^{mno}	32.36±1.40^{q}
T_3	0	5.01±0.14^{b}	47.33±0.48^{bcd}	1.62±0.11^{no}	111.71±1.22^{bc}	59.02±1.70^{ab}	62.41±1.87^{c}
	15	4.83±0.15^{cd}	46.17±0.22^{h}	1.79±0.09^{mn}	101.96±2.03^{ghi}	48.66±1.37^{d}	59.40±0.61^{def}
	30	4.69±0.11^{f}	45.28±0.44^{i}	2.43±0.08^{hij}	95.12±3.15^{jk}	42.41±1.44^{ef}	51.54±1.46^{hi}
	45	4.55±0.06^{g}	43.42±0.39^{kl}	2.81±0.10^{f}	86.13±3.09^{mno}	32.61±1.40^{ijkl}	43.50±1.95^{jk}
	60	4.43±0.13^{hij}	42.59±0.14^{n}	3.70±0.07^{bc}	77.27±1.18^{rst}	23.61±1.60^{nop}	34.48±1.72^{pq}
T_4	0	5.02±0.09^{b}	48.21±0.27^{ab}	0.83±0.08^{r}	115.29±2.68^{b}	60.75±0.79^{a}	65.36±1.32^{b}
	15	4.89±0.07^{c}	47.34±0.37^{bc}	1.10±0.06^{q}	106.59±3.10^{def}	57.72±1.49^{ab}	62.30±1.55^{cd}
	30	4.67±0.14^{f}	45.47±0.18^{h}	1.77±0.14^{mn}	97.24±3.54^{j}	40.19±0.47^{cd}	54.37±0.68^{gh}
	45	4.28±0.13^{lm}	44.15±0.46i	2.25±0.09^{j}	89.01±2.17^{lmn}	40.85±1.01^{efgh}	45.59±1.33^{j}
	60	4.17±0.08^{n}	43.12±0.05^{lm}	3.02±0.06^{e}	75.36±3.33st	28.28±0.47^{lmn}	36.59±0.89^{nop}
T_5	0	4.79±0.12^{de}	49.22±0.16^{a}	0.63±0.05^{s}	115.75±3.08^{b}	61.76±1.18^{a}	68.44±0.52^{a}
	15	4.66±0.16^{f}	48.92±0.31^{def}	0.84±0.12^{r}	109.73±1.85^{cd}	54.92±0.84^{bc}	65.46±1.90^{b}
	30	4.37±0.04^{jk}	48.20±0.40^{fgh}	1.34±0.09^{p}	98.68±2.11^{hij}	48.80±1.65^{d}	57.41±0.82^{f}
	45	4.17±0.10^{n}	47.41±0.35^{ij}	1.84±0.05^{lm}	90.09±3.08^{m}	41.64±1.58^{efg}	46.32±0.99^{j}
	60	4.07±0.10^{o}	46.31±0.23^{kl}	2..33±0.09^{ij}	81.92±2.90o^{pq}	29.57±1.52^{klm}	37.98±1.64^{mno}

T_0^*= mayonnaise containing 100% sunflower oil and eggs
T_0= mayonnaise containing 100% sunflower oil and guar gum
T_1= mayonnaise containing 100% pumpkin seed oil
T_2= mayonnaise containing 75% pumpkin seed oil; 25% sesame seed oil
T_3= mayonnaise containing 50% pumpkin seed oil; 50% sesame seed oil
T_4= mayonnaise containing 25% pumpkin seed oil; 75% sesame seed oil
T_5= mayonnaise containing 100% sesame seed oil

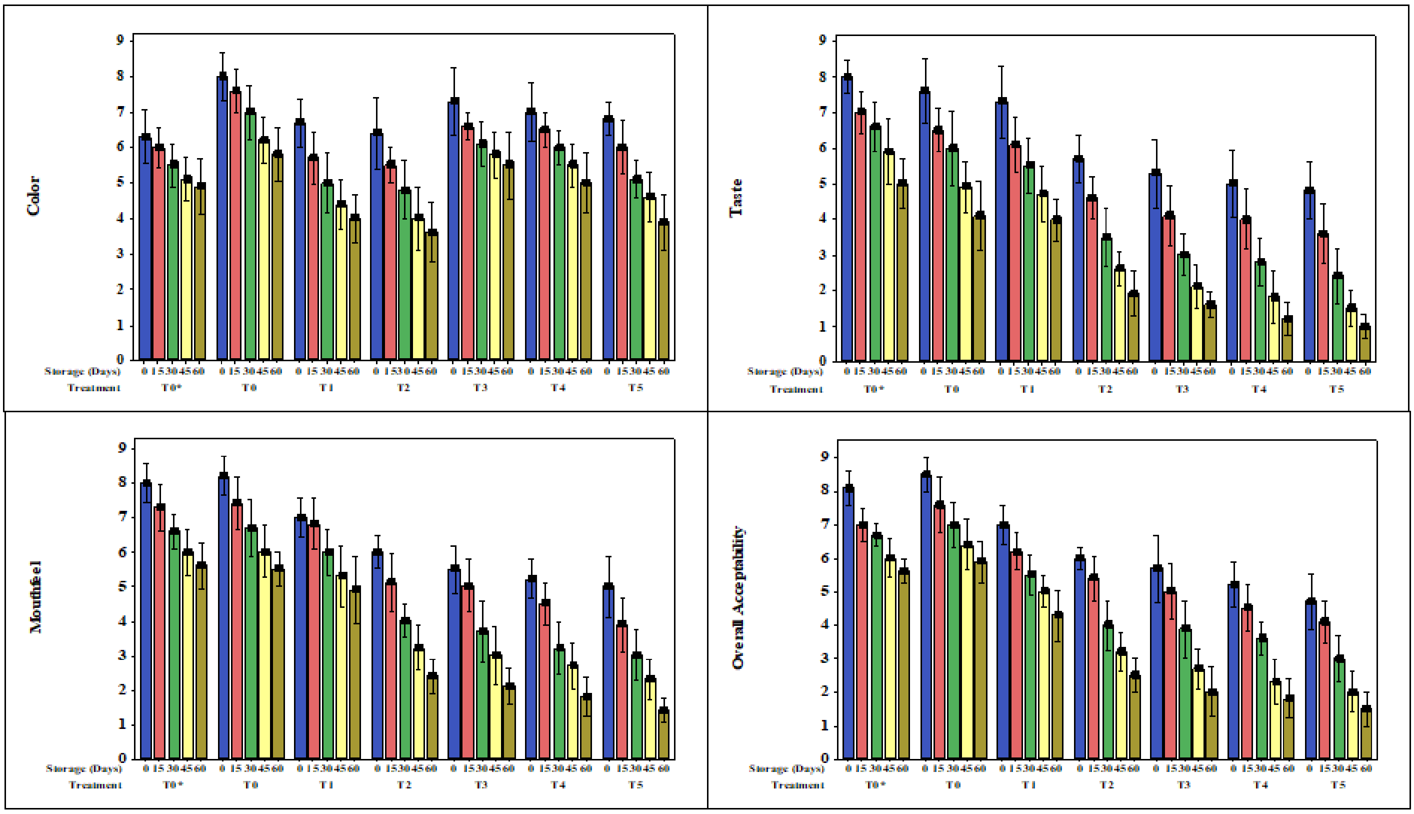

Figure 2. Comparison of different sensory characteristics of pumpkin and sesame seed oil mayonnaise

4. DISCUSSION

As a result of high FFA level in the oil might lead to greater oxidation and the formation of an unpleasant flavor and taste. The free fatty acid content of sesame seed oil found was 0.58±0.03(%) that agrees with that of Gharby *et al*. (2015) who reported FFA as 0.92±0.20(%). Peroxide is a good indication of fat, lipid, and oil oxidation. It is close to the findings of Dim *et al*. (2013) in which the sesame seed oil was extracted and characterized using solvent extraction with n-hexane as a solvent and had peroxide value of 2.00(meqO_2/kg of oil).

In current study, it is almost close to the results of research done by Iwuagwu *et al*. (2018) who reported iodine value of pumpkin seed oil as 104.45±0.27(g I_2/100g of oil). The iodine value of sesame seed oil is close to the findings of Chakraborty *et al*. (2017) in which sesame seed oil had iodine value of 112 (g I_2/100g of oil). The results are within the estimated range of iodine value which is 103-120(g I_2/100g of oil).

The specific gravity of pumpkin seed oil is close to Amin *et al*. (2019) who indicated the specific gravity of 0.90±0.01 of both native and hybrid varieties. Likewise, for sesame seed oil, the results are supported by Dim *et al*. (2013) who reported specific gravity as 0.920 which fell within the reference range. The results of saponification are supported by Rezig *et al*. (2012) in which the chemical composition and profile characterization of pumpkin (Cucurbita maxima) seed oil was done, and the pumpkin seed oil was found to had a saponification index of 175.00±1.30(mg KOH/g of oil). However, the saponification value of sesame seed oil are in accordance with that of 197±0.21(mg KOH/g of oil) reported by Nzikou *et al*. (2010) in which the characterization of seeds and oil of sesame (*Sesamum indicum* L.) was done.

The acid value of pumpkin seed oil is close to the literature by Kukeera *et al*. (2015) in which the acid value of pumpkin seed oil found was 3.74±0.64(mg KOH/g of oil). The acid value of sesame seed oil agrees with the research conducted by Borchani *et al*. (2010) in which the acid value of raw sesame oil found was 1.64±0.02(mg KOH/g of oil). The lower acid indicates the oil edibility and its suitability for industrial applications.

The refractive index of pumpkin seed oil is comparable to the findings by Mathangi (2018) who recorded the refractive index value of 1.47. The refractive index of sesame seed oil is supported by Dim *et al*. (2013) in which a refractive index of 1.472 was found in sesame oil. The smoke point of pumpkin seed oil is close to the results (120±0.10ºC) by Iwuagwu *et al*. (2018).

Pumpkin seed oil was high in UFAs with a total concentration of approximately 65% and contained around 21.1% of saturated fatty acids. Medium and short chain fatty acids or saturated fatty acids having carbon chains smaller than 14 carbon atoms were not identified in pumpkin seed oil as confirmed by previous studies. Linolenic and arachidic acid concentrations were also found in small amounts. These results are close to those reported by Nyam *et al*. (2009); Mitra *et al*. (2009); Rezig *et al*. (2012). However, the linoleic acid levels were found low.

In case of mayonnaise, pH of 3.60-4.00 is desired in the final product. The risk of microbial growth is considerably increased if the end product falls out of this range. The current study results are comparable to those of Adeleke *et al*. (2020) who investigated that the pH drops in salad creams which could be related to a rise in storage temperature because faster the sample (sugar) is broken down the more acid is produced. In a study conducted by Pazhv and Khavarpour (2019), a decrease in mayonnaise viscosity from with the increasing days was observed during the 30 days storage study. The study also revealed that viscosity decreases with the increase in the percentage of sesame seed oil.

FFA are produced from triacylglycerol by cleaving ester bonds due to high temperature, by action of lipase, and in the presence of moisture. As a result, a high FFA level in the oil might lead to greater oxidation and the formation of an unpleasant flavor and taste. The results of this research are close to the study done by Chukwu and Sadiq (2008) in which the values of free fatty acids increase with the progressing weeks. This increase in free fatty acid indicates the presence of the enzyme lipase. The findings of this study are in consistent with the research of Shabbir *et al*. (2015) who investigated that the decreasing iodine value indicates that the oxidation in mayonnaise increases with the increasing storage days.

In a study done by Ibrahim *et al*. (2013) the results showed that the color of mayonnaise samples varied over time. Food flavor is determined by taste. Mayonnaise has a sour taste due to the vinegar which is the main ingredient while the sugar adds sweetness, enhances flavor, and gives it a nice body. These findings are also consistent with those of Amin *et al*. (2014).

These results revealed that as the percentage of sesame seed oil increases it badly effects the mouthfeel of mayonnaise as it had the nuttier taste and aroma. The results are comparable to those of Shabbir *et al*. (2015) which indicated that both the storage period and different sesame sprout powder concentrations affect the mouthfeel of mayonnaise. The results for overall acceptability are in agreement with those of Ibrahim *et al*. (2013) in which the judges give the lower scores as they observe a decrease in overall acceptability of mayonnaise with the passing days.

5. CONCLUSION

The presence of fatty acids including oleic, palmitic, linoleic, and stearic acids suggested that sesame and pumpkin seed oils are beneficial food oils. These fatty acids are a good source of nutrition, and until now, pumpkin seeds were thought to be an agro-industrial waste. As a result, if correctly utilized, these oils could function as vegetable edible oils, and their production provides a means of utilizing renewable resources while also adding value to agricultural wastes and reducing the waste disposal problem faced by agro-based industries. It was found that adding sesame and pumpkin seed oil to the mayonnaise effectively delayed oxidation. According to the results of the current study, sesame and pumpkin seed oils have strong antioxidant potential and can be used in various foods to reduce oxidation when appropriate. Its nutritious value provides a potential for industrialization. However, there is need to work on sensory parameters.

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7. CONFLICTS OF INTERESTS

The authors declare no actual or potential conflict of interest including any financial, personal, or other relationships with other people or organizations.

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