

Probing the physicochemical impact of musk melon seed oil on mayonnaise

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Abstract

Owing to high consumption and industrial preparation of musk melon products, most of its byproducts are wasted without effective utilization. Musk melon agro-based waste material (seeds and peels) is an excellent source of antioxidants and phytochemicals. The purpose of this study was to improve the oxidative stability of mayonnaise by addition of musk melon seed oil. The study was conducted to check the physicochemical effect of musk melon seed oil in mayonnaise. Proximate analysis of seeds (i.e. moisture, crude fat, crude fiber, crude protein, ash, and carbohydrate content) was performed. Oil was extracted by using the cold press extraction method, and this oil was tested for different physicochemical analyses (i.e., saponification value, iodine number, specific gravity, 2,2-diphenyl-1-picrylhydrazyl [DPPH] value, viscosity, free fatty acid, and color). Physicochemical analysis was done during the storage period of 0, 20, 40, and 60 days, prior to performing sensory evaluation of mayonnaise. Data obtained from this analysis were further analyzed using statistical tools. A decreasing trend was observed for DPPH and peroxide values of mayonnaise with progression of days, thus showing that addition of musk melon seed oil decreased the production of free radicals. Hence, adding 40% musk melon seed oil showed the best result for overcoming the oxidation of mayonnaise and minimizing the production of free radicals. The data obtained from the statistical analysis indicated that the aroma and texture values of treatment T₅ were maximum, and the color and flavor of treatments T₄ and T₅ were high. The overall acceptability of treatment T₅ was high in which 40% of musk melon seed oil was used to combat the production of free radicals. In brief, waste material could be used for producing different types of products in the industry, rather than discarding the same, as it lessened the cost and provide a good quantity of nutrients.

Keywords: DPPH; mayonnaise; muskmelon seeds; oil; use of wastage

Introduction

Mayonnaise is an oil-in-water emulsion having extensive global consumption. It is the most preferably consumed and liked sauce and condiment globally. Nowadays, people, especially the young generation, have increased its consumption and want to add it to maximum food items. Mayonnaise, one of the oldest and most commonly used sauces globally, is a mixture of egg, oil, spices, and vinegar and used as a sandwich spread. Mayonnaise is a stable emulsion formed from approximately 65% vegetable oil and egg yolk (Singla *et al.*, 2013).

The food industry has some major tasks to produce low-cholesterol and low-fat mayonnaise and salad dressings having characteristics similar to that of full-fat products. Well-organized monitoring of products to evaluate suitable quality requires awareness of their physicochemical characteristics, such as emulsion stability, rheology, appearance, charge distribution, particle size, and flavor. The use of low-cholesterol egg yolk and plant-based ingredients in the preparation of such products may prove to be beneficial in reducing cholesterol (Ma and Boye, 2013). Phyto compounds that are natural and newly biosynthesized have achieved important nutritional, safety, and health benefits, compared to chemically synthesized antioxidants. However, natural and newly biosynthesized phytochemicals are rarely available in the commercial market and are used customarily during food processing and in food business (Hussain *et al.*, 2018).

Furthermore, the use of natural antioxidants and bioactive ingredients help to produce a functional healthy mayonnaise sauce (Mirzanajafi-Zanjani *et al.*, 2019). The apparent interaction of fats with several diseases, such as high blood pressure, obesity, and cardiovascular diseases, has shown the tendency toward low fat-containing products. Food processors face some major challenges in manufacturing novel food products, such as mayonnaise and salad dressings (Mozafari *et al.*, 2017). Rheological properties, texture profile, flavor, and viscosity analysis indicate that mayonnaise is a semi-solid emulsion made with starch if fat is reduced. Fat plays an important role in providing color, texture, and viscosity, but also causes several disorders and diseases in humans. The rheological properties indicate its hardness is 10 to 3 nm, firmness, and viscosity (Gaikwad *et al.*, 2019).

Mayonnaise has a different stability that can be estimated from some macroscopic defects, such as syneresis, and can be formulated through different formulations as well as under appropriate processing conditions, such as vegetable oil temperature, egg yolk weight, and homogenizer speed. Protein coverage at the interface and oil droplet distribution are some initial parameters to evaluate the long-term stability of mayonnaise (Ariizumi *et al.*, 2017).

Melon (*Cucumis melo* L.) has desirable attributes as a liable cash crop cultivated globally. Various groups of vine plants, such as *C. melo*, which had its origin in Iran and Pakistan, are mostly grown in hot climacteric conditions (Mansouri *et al.*, 2017). Cucurbits belongs to the family *Cucurbitaceae*, which consists of about 110 genera and 650–850 species and is distributed mainly in equatorial and semitropical regions of the world. Worldwide, the production of melon is approximately 3.1 billion tons, with a cultivated area of 1.2 million hectares. The yield of melon is about 0.2 million hectares (Food and Agriculture Organization of United Nations [FAO], 2019). In Pakistan, the total cultivated area of melon is approximately 37,000 hectares and the total melon production is 0.5 million tons; in Sindh (Pakistan), the total melon production is 41,000 tons (Government of Pakistan [GOP], 2016). In Pakistan, mainly in the Sindh region, Dharidar and Golden varieties are cultivated.

Musk melon seeds have a high content of protein and carbohydrates as well as 30%–40% of oil content, depending upon the varieties and regions in which it is cultivated (Rashid *et al.*, 2011). Seeds of musk melon are generally disposed of as agro-waste but can be utilized economically to extract muskmelon seed oil (Maran and Priya, 2015). Musk melon seeds have anti-oxidant, analgesic, anti-microbial, and anti-fertility properties (Mehra *et al.*, 2015). The plant seed oil has a large number of natural antioxidants and components. The musk melon seeds are consumed directly or after processing as well as in roasted form (Mallek-Ayadi *et al.*, 2018). The chemical composition and comprehensive study of lipids in musk melon seeds indicate that oil content ranged from 41.1% to 44.3%, protein from 34.2% to 39.8%, carbohydrates from 8.2% to 12.7%, crude fiber from 4.4% to 8.4%, soluble sugars from 3.8% to 4.3%, and minerals from 4.6% to 5.1%. The basic component of musk melon seeds is γ -tocopherol, which varies from 71.5% to 91.4% (Petkova and Antova, 2015). The seeds also have linoleic acid (denoted by L; 69.1%), followed by palmitic acid (denoted by P; 8.5%) and oleic acid (denoted by O; 16.4%). OLL (21.5%), POL (12.4%), PLL (15.9%), and LLL (24.8%) are the major triacylglycerols discovered in musk melon seeds. Crystallization and melting temperatures of musk melon seeds are -59°C and -5.12°C , respectively. Electronic nose analysis pointed out that more volatile compounds, along with a high amount of linolenic acid, are present in musk melon seed oil, compared to purified sunflower oil (Yanty *et al.*, 2008).

The seed grains are used for dressing confectionary, cake, bread, custard, and snack foods, rather than pistachios and almonds. Musk melon seeds can be used as a substitute of soybeans for preparation of milk. These are also useful for removing freckles and tan. In recent years, the seed kernels have been used as the basis of several soups, custards, and stews, where they act as emulsifying,

thickening, fat-binding, and flavoring agent (Milind and Kulwant, 2011).

Cold press and solvent extraction techniques are used to extract oil from wasted seeds. The yield of oil obtained from a cold press is higher than from solvent extraction, which is a lengthy process to get a good yield of oil (Ismail *et al.*, 2010). As musk melon seed oil has emulsifying, fat-binding, and anti-oxidative stability, it is also used in the preparation of mayonnaise to enhance its oxidative stability (Rashid *et al.*, 2011).

The purpose of the current research was to utilize musk melon seeds to produce useful products. In the current study, musk melon seed oil was extracted and its physicochemical properties were studied. The antioxidant effect of mayonnaise was also analyzed. The physicochemical parameters, such as peroxide value, acid value, saponification index, iodine value, specific gravity, refractive index and color, triacylglycerol, and fatty acids content, of melon seed oil were also determined. Thermal analyses and sensorial properties of bioactive substances were also examined to determine their nutritive value and potential applications (Mallek-Ayadi *et al.*, 2018).

Hence, following were the objectives of the present study:

- To assess the physicochemical effect of musk melon seed oil.
- To check the oxidative stability of prepared mayonnaise.
- To check the consumer acceptability of mayonnaise (incorporated musk melon seed oil).

Material and Methodology

Procurement of raw material

Musk melon seeds were procured from a local market located in district Faisalabad, Pakistan. Raw material for mayonnaise preparation (eggs, vinegar, salt, sugar, and regular sunflower cooking oil) was also procured from the local market of Faisalabad. All other materials, such as reagents and chemicals, required for research work were purchased from Azeem Scientific Store, Faisalabad, Pakistan. The material required for packaging was also procured from the local market.

Preparation of Sample

First, the drying of musk melon seeds was performed in a hot air oven (GZX-9023MBE, Boxun, China). Second, impurities were removed, followed by the grinding of musk melon seeds by using a steel stainless grinder (SKU 131088839, Electronica, Germany). The seed powder was filled in a suitable glass jar.

Proximate analysis of musk melon seeds

Proximate analysis of musk melon seeds, such as moisture, ash, fat, protein, and carbohydrates, was performed.

Moisture

The moisture content of musk melon seeds oil was determined using the methodology described by the American Association of Cereal Chemists (AACC; 2000).

$$\text{Moisture (\%)} = \frac{\text{Weight of original moisture of sample (g)} - \text{weight of dried sample (g)}}{\text{Weight of the original sample (g)}} \times 100.$$

Ash

The ash content of musk melon seeds was measured by using the methodology described by AACC (2000) and was calculated by the following formula:

$$\text{Ash (\%)} = \frac{\text{Weight of ash sample (g)}}{\text{Weight of the sample (g)}} \times 100.$$

Crude Protein

The crude protein content of musk melon seeds was determined by using the methodology described by AACC (2000):

$$\begin{aligned} \text{Nitrogen (\%)} &= \frac{\text{Titer of 0.1 N H}_2\text{SO}_4\text{ used} \times 0.0014 \times 250}{\text{Weight of the sample} \times \text{volume of the sample}} \times 100, \\ \text{Protein (\%)} &= \text{N (\%)} \times 6.25. \end{aligned}$$

Crude Fat

Fat content in musk melon seeds was determined by using the methodology described by AACC (2000). The weight of crude fat of musk melon seeds was determined by the following formula:

$$\text{Crude fat (\%)} = \frac{\text{Weight of hexane extract / residue}}{\text{Weight of the sample}} \times 100.$$

Crude Fiber

The fiber content of musk melon seeds was estimated by using the methodology described by AACC (2000). The fiber content was calculated using the following formula:

$$\text{Crude fiber (\%)} = \frac{\text{Weight of the residue} - \text{weight after ashing}}{\text{Weight of the sample (g)}} \times 100.$$

Carbohydrates

The carbohydrate content of musk melon seeds was estimated by using the methodology described by AACC (2000) and calculated by the following formula:

$$\text{Carbohydrates (\%)} = 100 - (\text{Moisture [\%]} + \text{ash [\%]} + \text{protein [\%]} + \text{fat [\%]}).$$

Extraction of oil

The oil from the musk melon seeds was extracted by using the cold press extraction method. The extraction of oil depended upon the pressure directly applied on the seeds. Then, musk melon seed oil was filtered using filter paper to remove impurities.

Physicochemical analysis of musk melon seed oil

Saponification value

The saponification value of musk melon seed oil was determined using the methodology described by Association of Official Analytical Chemists (AOAC, 2006). The musk melon seed oil sample was taken and its impurities, such as scum, moisture, and trace elements, were removed using a filter paper. The oil was completely dried and weighed to have 2.0 g of oil sample. This oil sample was transferred into a 250-mL Erlenmeyer flask, and mixed slowly with 25-mL alcoholic potassium hydroxide (KOH) solution (Merck, India) using a pipette. Then, this sample was refluxed in a water bath for 30 min. The sample was shaken vigorously, followed by the addition of 2–3 drops of phenolphthalein indicator and treated with 0.5-N hydrochloric acid (HCL) (Merck, Germany) until the pink color changes into a clear solution; this clarity was achieved after 1 h of boiling. Blank determination was also done along with sample determination. The saponification value of musk melon seed oil was calculated using the following formula:

$$\text{Saponification value (mg/g)} = \frac{56.1 (B-S) \times N \text{ of HCL}}{\text{Weight of the sample}}$$

where:

B = volume (mL) of typical hydrochloric acid (HCL) compulsory for blank.

S = volume (mL) of average hydrochloric acid (HCL) essential for the sample.

N = normality of the standard hydrochloric acid.

W = weight (g) of oil sample taken for testing.

Free fatty acids

The measurement of free fatty acids present in musk melon seed oil was estimated according to the standard method described by American Oil Chemist's Society (AOCS; 2006). About 10-mL musk melon seed oil was

taken in a conical flask; then, 25 mL 95% ethanol was poured into it and mixed until the oil sample turned miscible in ethanol. Then 2–3 drops of phenolphthalein indicator were added and shaken vigorously, and 0.1-N NaOH (Merck, Germany) was used to titrate the mixture with constant stirring until pink color was achieved. The free fatty acid (FFA) value of musk melon seed oil was calculated by using the following formula:

$$\text{FFA (\%)} = \frac{\text{Alkali used (mL)} \times N \times 28.2}{\text{weight of the sample (g)}}.$$

Peroxide value

The peroxide value of musk melon seed oil was calculated according to the standard method described by AOCS (2006). First, 5 mL of musk melon seed oil sample was taken in a 250-mL conical flask. Then, 30-mL 3:2 ratio acetic acid–chloroform (Catalog# 160-1; Ricca, Germany) solvent mixture was added and whirled for approximately 1 min until dissolved. After that, about 0–5 mL of standard potassium iodide solution was slowly pipetted using a Mohr pipette. This mixture was kept in a cool and dark place. After that, the sample solution was titrated against 0.1-N sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) solution. The solution was stirred continuously until yellow color was obtained. Subsequently, starch solution was used as an indicator, and constant shaking was done until blue color vanished. The peroxide value (PV) was calculated by the following formula:

$$\text{PV (meq/kg)} = \frac{(B-S) \times N \times 1,000}{\text{Weight of oil (g)}} \times 100$$

where:

N = normality of $\text{Na}_2\text{S}_2\text{O}_3$ solution.

B = volume of $\text{Na}_2\text{S}_2\text{O}_3$ used for blank.

S = volume of $\text{Na}_2\text{S}_2\text{O}_3$ used for sample.

Specific Gravity

The iodine number of musk melon seed oil was estimated according to the procedure described by AOAC (2006). First, dry pycnometer was filled with oil sample in such a manner that enmeshed the air bubbles when removed the cap of the side arm was. Then stopper was inserted and pycnometer was placed in a water bath for 30 min. The oil that came out of the opening of capillary tube was cautiously wiped off. The pycnometer was cleaned and dried and the cap was removed from the side arm after removing it from water bath. It was weighed with the sample; at the time of weighing, it was ensured that the temperature must be 30°C. The specific gravity of musk melon seed oil was computed by the following formula:

$$\text{Specific gravity} = \frac{\text{Weight of oil sample (g)}}{\text{Weight of water (g)}} = \frac{C-A}{B-A}$$

where:

A = weight of empty pycnometer.

B = weight of pycnometer filled with water.

C = specific gravity of the bottle filled with oil.

Iodine value

The iodine number of musk melon seed oil was estimated according to the procedure described by AOAC (2006). About 5 mL of oil sample was taken in an Erlenmeyer flask. About 25 mL of carbon tetrachloride (CCl_4) solution was added with continuous stirring, followed by the addition of Wij's solution. All the contents were mixed thoroughly. The solution was allowed to stand for approximately 30 min in a dark place. The distillation was performed using 10% potassium iodide solution with 20 mL of distilled solution. The contents of the flask were titrated against 0.1-N $\text{Na}_2\text{S}_2\text{O}_3$ solution, and starch solution was used as an indicator. A blank reading was also conducted, and the given formula was used to calculate the iodine value of musk melon seed oil:

$$\text{Iodine value} = \frac{(B - S) \times N \times 12.69}{\text{Weight of the sample}}$$

where:

B = volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution used to run blank sample.

N = volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution consumed by the sample.

S = normality of $\text{Na}_2\text{S}_2\text{O}_3$ solution.

Color

Color variations in musk melon seed oil were estimated with a colorimeter according to method described by Abdulkarim *et al.* (2005). To determine the color of musk melon seed oil, Lovibond tintometer was used having L^* a^* b^* color scales, and every scale elaborated different adjustments of red, green, and yellow colors consequently. The change in color or hue was noticed and the given formula was used to determine or adjust musk melon seed oil's final color.

Viscosity

The viscosity of musk melon seed oil was analyzed according to the methods described by Lalas and Tsaknins (2002). The Brook-field DV111 digital model of rheometer was used at a constant temperature of 30°C LV₂ spindle at 10, 20, and 30 revolution per minute (rpm) respectively.

Fatty acid profile

Chromatography technique was used to determine the composition of fatty acids according to the method reported by Kaphueakngam *et al.* (2009). First, the fatty acid methyl esters (FAME) were prepared through the transesterification of oil. Then, 100 μL of musk melon

seed oil was swirled with 5 mL of heptane and 250- μL sodium methoxide. The mixture was swirled until three layers were formed. The epical layer consisted of methyl esters and the second and third layers consisted of impurities and foam, respectively. The upper layer was collected in a vial with the help of a micro-syringe and used for Gas chromatography (GC) analysis.

Antioxidant activity

The antioxidant value was measured with 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging capacity estimation by the methodology described by Sun and Ho (2005). First, completely mix the 1 mL of methanol (MeOH) of DPPH with approximately 1 mL of musk melon seed oil sample. After mixing, the oil sample was allowed to stand in a dark place at an ambient temperature for almost 30 min. Absorbance of the solution was estimated against 517-nm blank reagent. The antioxidant value was calculated as the percentage of inhibition of DPPH radical.

Preparation of mayonnaise

Mayonnaise was prepared in laboratory with regular sunflower oil and musk melon seed oil blended in different concentrations as described in the treatment plan. A variety of blended mixtures of musk melon seed oil and sunflower oil were created for producing mayonnaise. The treatment plan is discussed in Table 1.

Product analysis during storage

The prepared mayonnaise samples were packed in plastic cups and stored at 25°C for investigation of quality

Table 1. Treatment plan.

Treatments	Regular sunflower oil content (%)	Musk melon oil content (%)	Butylated hydroxy toluene (BHT)
T ₀ (control)	100	0	0
T ₁	99.99	—	0.01
T ₂	90	10	—
T ₃	80	20	—
T ₄	70	30	—
T ₅	60	40	—

T₀ = control.

T₁ = mayonnaise containing 0.01% BHT.

T₂ = mayonnaise containing 10% musk melon seed oil.

T₃ = mayonnaise containing 20% musk melon seed oil.

T₄ = mayonnaise containing 30% musk melon seed oil.

T₅ = mayonnaise containing 40% musk melon seed oil.

characteristics and oxidation stability at 0, 20, 40, and 60 days of storage.

Oxidative stability tests

Peroxide value

Peroxide value was calculated by measuring iodine, formed from the reaction between hydrogen peroxide and iodine in the process described in AOCS (2006). The prepared 250-mL mayonnaise samples were taken in an Erlenmeyer flask. Then about 30 mL of mixture of glacial acetic acid and chloroform was added. The sample solution was titrated against 0.1-N $\text{Na}_2\text{S}_2\text{O}_3$ solution prepared by adding freshly prepared potassium iodide (KI) solution. The mixture was shaken continuously till the disappearance of yellow color. After that, 0.5 mL of starch solution, an indicator, was added to the mixture with continuous shaking until the disappearance of yellow color. A blank sample was also run separately and the peroxide value was calculated by the following formula:

$$\text{PV (meq/kg)} = \frac{(B - S) \times N \times 1,000}{\text{Weight of oil (g)}} \times 100$$

where:

N = normality of $\text{Na}_2\text{S}_2\text{O}_3$ solution.

B = volume of the $\text{Na}_2\text{S}_2\text{O}_3$ used for blank sample.

S = volume of $\text{Na}_2\text{S}_2\text{O}_3$ used for mixture sample.

p-Anisidine value

The standard method of IUPAC (1987) was followed for the estimation of p-anisidine value of mayonnaise. The test was conducted after some simple tasks, such as melting at 60–70°C temperature, filtering of samples using filter paper, then complete mixing of samples. The samples were homogenized, and 0.3 g of the same was taken in a volumetric flask of 25 mL capacity to 0.1 mg closest. Then iso-octane, about 5–10 mL, was taken and dissolved completely in the sample to make the final volume with the same solution. The measurement of test sample was done by calculating absorbance after applying 350-nm wavelength. For reference, iso-octane cells were filled as blank. After that, 5 mL of iso-octane was taken in a second test tube. Then anisidine reagent was added to the test tube using an automatic pipette. Wavelength of 350 nm was used to run the sample, and absorbance was estimated after 10 min in the sample cells of the first test tube and the result was taken as vacant in the suggestion cell for the second test tube.

Antioxidant potential test

DPPH radical scavenging assay

DPPH radical scavenging assay was conducted according to the procedure described by Sun and Ho (2005).

Mayonnaise samples, 3 mL, were taken and diluted with methanol. Then these samples were mixed with DPPH (3 mL) in methanol (2.0×10^{-4}) to obtain the final concentration of DPPH. All the samples were shaken vigorously before incubation performed for approximately 30 min. A wavelength of 517 nm was used to calculate the absorbance value of all the samples.

Sensory analysis

A hedonic scale having 9 points ranging from extreme liking (value of 9) to extreme disliking (value of 1) was used for sensory analysis of all mayonnaise samples (Meilgaard *et al.*, 2007). The sensory parameters of mayonnaise samples evaluated were flavor, color, appearance, mouth feel, and overall acceptability for 0, 20, 40, and 60 days. The sensory evaluation laboratory of NIFSAT, University of Agriculture, Faisalabad, was used to conduct sensory analysis. A very comfortable environment with separate white fluorescent lights was available for panelists. The unsalted crackers and distilled water were also provided to neutralize the mouth feel when panelists were testing different mayonnaise samples. Samples were presented in random to PhD faculty members and scholars to prevent bias. Samples were scored according to the suitability of each characteristic.

Storage stability

The storage stability study was performed at different storage intervals. Mayonnaise samples were filled in separate plastic cups and stored at a temperature of approximately $25 \pm 5^\circ\text{C}$ for investigation of quality attributes and antioxidative stability at 0, 20, 40, and 60 days of time intervals.

Statistical analysis

Data were subjected to analysis to find the level of significance as described by Montgomery (2008). Statistical analysis was done to determine comparison between mean values and to find out the level of significance for each parameter.

Results and Discussion

The present study was designed to examine the physicochemical impact of musk melon seed oil on mayonnaise. The stability of oil keeps in view relevant to the antioxidant stability of artificial antioxidants in all tested samples of mayonnaise and it is crucial to replace artificial antioxidants with some secure natural antioxidants.

The observed results were organized, statistically investigated, and discussed below:

Approximate analysis of musk melon seeds

Moisture test

Moisture content (%) of musk melon seeds as shown in Table 2 was $3.23 \pm 0.16\%$. Mehra *et al.* (2015) observed that the moisture content of musk melon seeds was 2.358%, and demonstrated that the moisture content of musk melon seeds was $3.5 \pm 0.12\%$.

Ash test

Ash content (%) of musk melon seeds as shown in Table 2 was $4.86 \pm 0.24\%$. Mehra *et al.* (2015) demonstrated that the ash content of musk melon seeds was 4.8%, and Amin *et al.* (2018) described the ash content of musk melon seed as $5.10 \pm 0.05\%$.

Crude protein test

The content of protein in musk melon seeds was $31.37 \pm 0.45\%$, as shown in Table 2. Mehra *et al.* (2015) demonstrated that the content of crude protein in musk melon seeds was 32.80%, and Amin *et al.* (2018) described that the crude protein content in these seeds was $30.0 \pm 0.00\%$.

Crude fat test

The content of crude fat in musk melon seeds was $35.70 \pm 0.63\%$, as shown in Table 2. Mehra *et al.* (2015) reported that the crude fat content of musk melon seeds was 37.167%, and Amin *et al.* (2018) investigated that the crude fat content in these seeds was $38.25 \pm 0.31\%$.

Crude fiber test

The estimated crude fiber content in the selected sample was $6.67 \pm 0.47\%$, as tabulated in Table 2. It was compared with $4.5 \pm 0.1\%$ of the dietary fiber present in musk melon seeds described by Petkova and Antova (2015), and according to Amin *et al.* (2018), the content of dietary fiber in musk melon seeds was $9.53 \pm 0.47\%$.

Table 2. Proximate analysis of musk melon seeds.

Parameters	Content (%)
Moisture	3.23 ± 0.16
Ash	4.86 ± 0.24
Crude protein	31.37 ± 0.45
Crude fat	35.70 ± 0.63
Crude fiber	6.67 ± 0.47
Carbohydrates	24.40 ± 0.70

N = 2; data are shown as mean value \pm standard deviation (SD).

Carbohydrates

Carbohydrates are starch and sugar that are mainly composed of carbon, hydrogen, and nitrogen and used as a source of energy. The estimated carbohydrate content of the sample was $24.40 \pm 0.70\%$, as mentioned in Table 2. This value was compared with the carbohydrate content of $17.08 \pm 0.03\%$, as described by Amin *et al.* (2018) and 8.2 to 12.7% described by Petkova and Antova (2015).

Physicochemical analysis of musk melon seed oil

Saponification value

The saponification value of oil is described as a measurement used to describe the functionality of oil, and is also used to compare molecular mass. Fundamentally, it is the amount of alkali KOH (mg/g) required to break free fatty acids to saponify esters that are shown in definite amount of substances (1 g of fat or oil). The estimated value of musk melon seed oil was 138.58 ± 1.09 mg KOH/g (Table 3), compared with the saponification value of 131.95 ± 0.06 mg KOH/g. The estimated value of musk melon seed oil was also compared with 197.17 mg KOH/g saponification value described by Mehra *et al.* (2015).

Free fatty acid value

The free fatty acid content is defined as the degree of strength where glyceride compounds present in oil are impaired through the activity of lipase. Free fatty acids are responsible for purity as well as freshness of oil. The estimated free fatty acid value of musk melon seed oil was $0.33 \pm 0.05\%$ (Table 3). A low free fatty acid value indicates that musk melon seed oil has a good nutritional value. This value was also compared with 0.31% as estimated by Mallek-Ayadi *et al.* (2018) and $2.13 \pm 0.02\%$ as estimated by Shafi *et al.* (2019).

Peroxide value

The peroxide value (PV) is usually considered as the rancidity of oil caused by oxidation. It is defined as the content of peroxide oxygen present in 1 L of oil or fat. The estimated peroxide value of musk melon seed oil was $7.02 \pm 0.49\%$, as mentioned in Table 3. This peroxide value was compared with the peroxide value described by Shafi *et al.* (2019).

Specific gravity

Specific gravity is used to estimate the purity of fats and oils. The specific gravity may also be considered as the ratio of the density of oil to the density of the reference compound (water). Specific gravity is always <1 and the normal value for fats and oils is 0.85–0.959 g/cm³. The estimated specific gravity in the study was 0.86 ± 0.04 g/cm³ (Table 3). This value was compared with the specific gravity value of 0.91 ± 0.00 g/cm³ described by Mallek-Ayadi *et al.* (2018).

Table 3. Physicochemical analysis of musk melon seed oil.

Physicochemical analysis	Mean value ± standard deviation
Saponification value (mg/KOH)	138.58 ± 1.09
Free fatty acids (%)	0.33 ± 0.05
Peroxide value (meq/kg)	7.02 ± 0.49
Specific gravity (kg/m ³)	0.86 ± 0.04
Iodine value (gI ₂ /100 g)	135.85 ± 6.7
Color L*	47.90 ± 0.28
Color a*	-4.67 ± 0.12
Color b*	13.34 ± 0.60
Viscosity (MPa.s)	90.07 ± 0.57
DPPH	32.63 ± 0.93

N = 2; data are shown as mean value ± standard deviation (SD)
DPPH: 2,2-diphenyl-1-picrylhydrazyl.

Iodine value

The iodine value can be defined as the iodine number used by 100 g of fats and oils. The degree of unsaturation is high if more iodine value is determined in edible fats and oils. The estimated iodine value of musk melon seed oil was 135.85 ± 6.7 g I₂/100 g of oil, which was determined by the method described in AOAC (2006) (Table 3). This value was also compared with the value of 139.50 ± 0.53 g I₂/100 g of oil described by Mallek-Ayadi *et al.* (2018).

Color

The value of oil depends on its color. The visual appearance of the product is a critical factor for consumer satisfaction and color is an important factor in this regard. On the basis of color perception, consumers either accept or reject a food product. These color parameters mainly include a* (redness/greenness), b* (yellowness/blueness), and L* (lightness). The estimated color value of muskmelon seed oil was L*: 47.90 ± 0.28, a*: -4.67 ± 0.12, b*: 13.34 ± 0.60 (Table 3). This value was compared with L*: 48.42 ± 0.84, a*: -5.81 ± 0.18, and b*: 15.29 ± 0.73, described by Mallek-Ayadi *et al.* (2018). The estimated color values of musk melon seed oil were compared with the value (28.31 Y + 1.21 R), and the respective values of L*, a*, and b* were 64.6, 1.2, and 29.2, as determined by Azhari *et al.* (2014).

Viscosity

The viscosity of oil is used to describe the quality attributes of oil. Liquid viscosity is essentially related to the designing of processing equipment used in the edible fat and oil industry. Hence, the viscosity of oil is defined as the amount of fluid resistant to flow whenever it is subjected to shear stress. The estimated value of viscosity of the musk melon seed oil was 90.07 ± 0.57 MPa.s (Table 3) according to the methods described by Lalas and

Table 4. Free fatty acids profile of musk melon seed oil.

Free fatty acids profile	Mean value ± standard deviation
Myristic acid (C14:0)	0.24 ± 0.01
Palmitic acid (C16:0)	11.27 ± 0.50
Palmitoleic acid (C16:1)	1.73 ± 0.08
Stearic acid (C18:0)	5.67 ± 0.28
Oleic (C18:1)	14.63 ± 0.06
Linoleic (C18:2)	66.63 ± 0.72
Linolenic (C18:3)	0.25 ± 0.02

N = 2; data are shown as mean value ± standard deviation (SD).

Tsaknins (2002) and mentioned in Table 4. This value of viscosity was compared to 90.75 ± 0.25 MPa.s described by Mallek-Ayadi *et al.* (2018).

Fatty acids profile

A fatty acid is a carboxylic acid with a long aliphatic chain that could be unsaturated or saturated. The nutritional value of vegetable fats and oils can be estimated based on composition of fatty acids. The musk melon seed oil was infused into a chromatographic apparatus and the temperature was maintained at 220°C. The temperature of the broiler was maintained at 175°C and changed by an increment of about 3°C step by step up to a level of 220°C. The fatty acid results of musk melon seed oil sample are presented in Table 4, which demonstrates that the oil had major unsaturated fatty acids, such as oleic acid (C18:1) 14.63 ± 0.06%, linoleic acid (C18:2) 66.63 ± 0.72%, and linolenic acid (C18:3) 0.25 ± 0.02%.

Antioxidant activity

The antioxidant value is measured through DPPH radical scavenging capacity estimation by the methodology described by Sun and Ho (2005). DPPH is an organic compound of dark green color and found in crystalline powder form consisting of some stable molecules or free radicals. The DPPH value of musk melon seed oil was 32.63 ± 0.93% (Table 4). This value was compared to the DPPH value described by Mallek-Ayadi *et al.* (2018).

Preparation of mayonnaise samples

Salt, sugar, and white pepper were first mixed with egg and vinegar in an electric pan mixer at a liquefying velocity for 5 s. To begin with, the mixture of sunflower oil and musk melon seed oil in different proportions was added slowly to the system, and more rapidly after the mass began to thicken. Then, butylated hydroxy toluene (BHT) was added. All ingredients were mixed in a blender for 5 min. Mayonnaise samples were packed into clean glass

bottles with screw caps and stored at room temperature ($20^{\circ}\text{C} \pm 2^{\circ}\text{C}$). The samples were used on next day for organoleptic evaluation.

Product analysis during storage study

All samples of mayonnaise were packed in a plastic container and stored at a temperature of $25\text{--}28^{\circ}\text{C}$. The stored samples were used for antioxidative stability and all quality characteristics at time intervals of 0, 20, 40, and 60 days of storage.

Oxidative stability test

Peroxide value

The results showed that there was a significant interaction between all treatments. The interaction effect of days and treatments was significant. This study showed that the peroxide value was maximum for the control treatment. At the end of 60 days of storage time, the lowest peroxide value was observed for treatment T_5 (Table 5). These results further showed that peroxide value could be reduced by increasing musk melon oil seed value. These findings were similar to the results of Zeb (2016), who studied the phenolic content and antioxidant activity of melon seeds and concluded that the seeds could be used as an excellent and natural antioxidant and for fortification of different food products. According to Landrault *et al.* (2001), all antioxidants remain effective for a specific time and lose their activity after specified period. Natural oxidants should be used to prevent loss of activity so that oxidation could be reduced in mayonnaise and other oil-containing products (Anwar *et al.*, 2003).

Para-anisidine VALUE (p-AV)

Table 6 shows that slight increase in p-AV was observed up to 20 days of storage; then, a considerable increase in

p-AV was recorded up to the end of the storage period (60 days). The highest value of p-AV was recorded for the control treatment. Treatment T_5 showed the lowest p-AV value. A significant effect was observed for different treatments. The interaction effect of treatments and days was also significant. These findings showed that muskmelon seed oil contains high levels of phenolic compounds; these compounds have antioxidant effects and show anti-hydrolytic effects during storage. The phenolic and antioxidant activity of *Cucumis melo var. cantalupensis* showed that high antioxidant activity was in parallel with their higher phenolic contents. Hence, these results were similar to those of Ibrahim and El-Masry (2016). The finding results are in agreement with these findings (peanut skins) ethanol 80% extracts (200 ppm) showed the lowest increase in p-AV compared with other extracts and BHA at the same ratio (200 ppm) (Ismail *et al.*, 2010). The resulting p-AV value was compared to seed butter oil obtained by using pumpkin seeds, sunflower seeds, and sesame seeds; a significant increase in the p-AV value of seed butter oil was observed due to temperature (Chien, 2015).

Antioxidant potential test

DPPH radical scavenging assay

The antioxidant potential of musk melon seed oil increases with increase in its concentration. Results in Table 7 demonstrate that there is significant interaction between all the treatments. The interaction effect of days and treatments is also significant. Treatment T_5 showed a high antioxidant potential throughout the storage time of 60 days. These findings are similar to those of Ibrahim and El-Masry (2016), who studied the phenolic content and antioxidant activity of Cantaloupe (*Cucumis melo var. cantalupensis*). The results of DPPH test indicated that extract components could scavenge free radicals because they had a hydrogen-donating mechanism. They

Table 5. Mean treatment for peroxide value of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T_0	0.727 ± 0.045	2.733 ± 0.050	10.613 ± 0.020	13.777 ± 0.076	6.96250 ^a
T_1	0.643 ± 0.047	3.740 ± 0.011	5.047 ± 0.035	6.597 ± 0.015	4.00675 ^c
T_2	0.743 ± 0.025	1.760 ± 0.062	6.627 ± 0.015	7.530 ± 0.052	4.84000 ^b
T_3	0.733 ± 0.045	1.657 ± 0.032	3.953 ± 0.055	7.220 ± 0.031	3.69075 ^d
T_4	0.837 ± 0.020	1.623 ± 0.030	4.727 ± 0.047	6.920 ± 0.012	3.58225 ^e
T_5	0.541 ± 0.031	1.713 ± 0.049	4.723 ± 0.051	6.542 ± 0.043	3.37975 ^f
Mean	0.8448 ^d	2.6452 ^c	7.1380 ^b	9.7172 ^a	

T_0 = control; T_1 = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T_2 = mayonnaise containing 10% musk melon seed oil; T_3 = mayonnaise containing 20% musk melon seed oil; T_4 = mayonnaise containing 30% musk melon seed oil; T_5 = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value \pm standard deviation (SD).

Table 6. Mean treatment value of para-anisidine of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T ₀	3.353 ± 0.040	4.91 ± 0.072	6.19 ± 0.081	7.063 ± 0.066	5.37917 ^a
T ₁	3.177 ± 0.041	3.89 ± 0.075	6.27 ± 0.065	6.917 ± 0.060	5.06333 ^b
T ₂	3.054 ± 0.039	3.35 ± 0.091	5.35 ± 0.083	6.102 ± 0.055	4.51758 ^c
T ₃	3.044 ± 0.029	3.58 ± 0.072	5.18 ± 0.066	5.927 ± 0.075	4.43350 ^d
T ₄	2.721 ± 0.045	3.47 ± 0.082	4.46 ± 0.090	5.143 ± 0.068	3.94917 ^e
T ₅	2.542 ± 0.034	3.34 ± 0.055	4.24 ± 0.091	4.953 ± 0.075	3.76917 ^f
Mean	2.98128 ^d	3.79222 ^c	5.28389 ^b	6.01722 ^a	

T₀ = control; T₁ = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T₂ = mayonnaise containing 10% musk melon seed oil; T₃ = mayonnaise containing 20% musk melon seed oil; T₄ = mayonnaise containing 30% musk melon seed oil; T₅ = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

Table 7. Mean of DPPH treatment values of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T ₀	28.897 ± 0.0379	27.067 ± 0.0404	13.443 ± 0.0351	10.917 ± 0.0306	27.9625 ^a
T ₁	29.047 ± 0.0351	28.901 ± 0.0529	19.170 ± 0.0529	14.823 ± 0.0416	27.8467 ^b
T ₂	30.957 ± 0.0321	31.077 ± 0.0321	20.053 ± 0.0551	15.860 ± 0.0624	25.6208 ^c
T ₃	32.953 ± 0.0208	33.143 ± 0.0451	20.243 ± 0.0416	16.143 ± 0.0681	24.4867 ^d
T ₄	33.053 ± 0.0404	33.833 ± 0.0379	24.833 ± 0.0513	20.031 ± 0.0529	22.9850 ^e
T ₅	33.080 ± 0.0557	34.410 ± 0.05	23.921 ± 0.0361	19.987 ± 0.0306	20.0808 ^f
Mean	31.3311 ^b	31.4033 ^a	20.2939 ^c	16.2933 ^d	

T₀ = control; T₁ = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T₂ = mayonnaise containing 10% musk melon seed oil; T₃ = mayonnaise containing 20% musk melon seed oil; T₄ = mayonnaise containing 30% musk melon seed oil; T₅ = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

could also stop the initiation of free radical-mediated chain reactions. Moreover, this also showed that due to extract scavenging ability, they could be used as therapeutic agents. The impact of antioxidants on DPPH radical scavenging is due to their hydrogen-donating ability and DPPH is a stable free radical and accepts an electron or hydrogen radical to become a stable molecule.

Sensory analysis

Hedonic scale with 9 points, ranging from extreme liking (point 9) to extreme dislike (point 1) was used for sensory analysis (Meilgaard *et al.*, 2007).

Aroma of mayonnaise

The results are shown in Table 8. There was a significant interaction between different treatments and days. The results showed that on the first day of storage, all treatments had the best score, but with the passage of time, their aroma changed. Storage time had a negative effect on treatments. Treatment T₀ (control) had less score

because there was no antioxidant and seed oil. Treatment T₅ showed the best result because it had 40% seed oil that acted as a natural antioxidant. The addition of seed oil changes aroma but not to a great level.

Flavor of mayonnaise

The results regarding flavor are shown in Table 9. On the first day of storage, all samples gave the best results for flavor, but with the passage of storage time, the flavor also tended to reduce. The reason was the production of some volatile compounds due to oxidation that occurred during storage. Treatment T₅ showed the best results after 60 days of storage because the oxidation was low, compared to other treatments. Treatment T₁ showed minimum result because there was a minimum addition of musk melon seed oil and antioxidants.

Color of mayonnaise

The results for color are shown in Table 10. There was significant interaction between all treatments. There

Table 8. Mean of treatments for the aroma of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T ₀	7.1 ± 0.1	6.9 ± 0.1	6.5 ± 0.05	5.8 ± 0.1	6.57 ^f
T ₁	7.4 ± 0.1	7.3 ± 0.1	6.4 ± 0.1	5.9 ± 0.1	6.75 ^e
T ₂	7.6 ± 0.1	7.2 ± 0.1	6.7 ± 0.1	6.5 ± 0.0	7.01 ^d
T ₃	7.7 ± 0.1	7.3 ± 0.1	6.8 ± 0.1	6.6 ± 0.1	7.10 ^c
T ₄	7.8 ± 0.1	7.4 ± 0.1	6.9 ± 0.1	6.7 ± 0.1	7.20 ^b
T ₅	7.9 ± 0.2	7.6 ± 0.1	7.4 ± 0.1	6.8 ± 0.1	7.42 ^a
Mean	9.10 ^a	8.74 ^b	8.14 ^c	7.66 ^d	

T₀ = control; T₁ = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T₂ = mayonnaise containing 10% musk melon seed oil; T₃ = mayonnaise containing 20% musk melon seed oil; T₄ = mayonnaise containing 30% musk melon seed oil; T₅ = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

Table 9. Mean of treatments for flavor of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T ₀	7.3 ± 0.1	7.1 ± 0.1	6.9 ± 0.1	5.9 ± 0.1	6.8 ^c
T ₁	6.8 ± 0.1	6.7 ± 0.1	5.8 ± 0.1	5.6 ± 0.1	6.2 ^e
T ₂	7.5 ± 0.3	6.9 ± 0.1	6.8 ± 0.1	5.7 ± 0.1	6.7 ^d
T ₃	7.6 ± 0.2	7.2 ± 0.1	6.9 ± 0.1	5.6 ± 0.2	6.8 ^c
T ₄	7.7 ± 0.1	7.6 ± 0.1	7.0 ± 0.1	6.9 ± 0.1	7.3 ^b
T ₅	7.8 ± 0.1	7.7 ± 0.0	7.4 ± 0.1	6.8 ± 0.1	7.4 ^a
Mean	8.94 ^b	10.8 ^a	8.16 ^c	7.3 ^d	

T₀ = control; T₁ = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T₂ = mayonnaise containing 10% musk melon seed oil; T₃ = mayonnaise containing 20% musk melon seed oil; T₄ = mayonnaise containing 30% musk melon seed oil; T₅ = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

Table 10. Mean of treatments for the color of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T ₀	7.2 ± 0.1	6.9 ± 0.1	6.7 ± 0.1	5.9 ± 0.1	6.6 ^f
T ₁	7.3 ± 0.1	7.0 ± 0.1	6.9 ± 0.1	6.6 ± 0.1	6.9 ^e
T ₂	7.5 ± 0.1	7.2 ± 0.1	6.8 ± 0.1	6.5 ± 0.1	7.0 ^d
T ₃	7.6 ± 0.1	7.3 ± 0.1	6.7 ± 0.1	6.8 ± 0.1	7.1 ^c
T ₄	7.7 ± 0.1	7.3 ± 0.1	7.0 ± 0.1	8.1 ± 0.2	7.5 ^b
T ₅	7.8 ± 0.1	7.4 ± 0.1	7.7 ± 0.1	8.0 ± 0.0	7.7 ^a
Mean	9.02 ^a	8.62 ^b	8.36 ^c	8.38 ^d	

T₀ = control; T₁ = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T₂ = mayonnaise containing 10% musk melon seed oil; T₃ = mayonnaise containing 20% musk melon seed oil; T₄ = mayonnaise containing 30% musk melon seed oil; T₅ = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

was a noticeable effect of storage on the color and appearance of mayonnaise. The color of mayonnaise tended to become descend with time. The control treatment showed the lowest score because there was no addition of musk melon seed oil and antioxidants. Treatments T_2 and T_5 showed the best results for color and appearance, compared to other treatments because the increased concentration of musk melon seed oil had a negative impact on the color and appearance of mayonnaise.

Texture of mayonnaise

Texture is also considered one of the most important features to check the quality of any food product. The results for texture are shown in Table 11. There was a significant interaction between treatments and day of storage. The results showed that on the first day of storage, all treatments had the best score, but with time, their texture changed. Storage time had a negative

effect on treatments. Treatment T_0 (control) had minus score because there was no antioxidant and seed oil. Treatments T_4 and T_5 showed the best result because they had 40% seed oil that acted as a natural antioxidant. The addition of seed oil changes the texture but not to a greater level.

Overall acceptability

The results for overall acceptability are shown in Table 12. There was a significant interaction between all treatments. The interaction effect of treatments and storage days was also significant. After 60 days of storage, treatment T_0 (control) with no seed oil and BHT showed the maximum value for overall acceptability, while the treatment with 60% saponification (SOF) and 40% musk melon seed oil showed the highest value. These findings also demonstrated that storage time had a negative effect on product quality. This was because the antioxidant activity decreased with time; therefore, after a long storage

Table 11. Mean of treatments for texture of mayonnaise during 60 days of storage.

Treatment	Storage (days)				Mean
	0	20	40	60	
T_0	6.9 ± 0.1	6.7 ± 0.1	6.8 ± 0.01	5.8 ± 0.1	5.24 ^f
T_1	6.8 ± 0.1	6.4 ± 0.1	7.1 ± 0.1	6.9 ± 0.1	6.72 ^e
T_2	7.3 ± 0.1	7.2 ± 0.1	6.9 ± 0.1	6.5 ± 0.1	6.97 ^d
T_3	7.4 ± 0.1	7.3 ± 0.1	6.7 ± 0.1	6.9 ± 0.2	7.00 ^c
T_4	7.5 ± 0.1	7.4 ± 0.1	7.3 ± 0.2	7.1 ± 0.1	7.30 ^a
T_5	8.1 ± 0.1	7.2 ± 0.1	6.9 ± 0.2	6.8 ± 0.1	7.25 ^b
Mean	8.8 ^a	8.4 ^b	8.3 ^c	8.0 ^d	

T_0 = control; T_1 = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T_2 = mayonnaise containing 10% musk melon seed oil; T_3 = mayonnaise containing 20% musk melon seed oil; T_4 = mayonnaise containing 30% musk melon seed oil; T_5 = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

Table 12. Mean of treatment for overall acceptability of mayonnaise during 60 days of storage.

Treatment	Storage				Mean
	0	20	40	60	
T_0	8.1 ± 0.2	8.0 ± 0.1	7.9 ± 0.5	7.8 ± 0.5	7.95 ^b
T_1	6.4 ± 0.4	6.5 ± 0.2	5.8 ± 0.1	5.9 ± 0.1	6.15 ^f
T_2	7.5 ± 0.1	7.4 ± 0.1	6.9 ± 0.2	6.3 ± 0.1	7.02 ^e
T_3	7.6 ± 0.2	7.4 ± 0.1	7.0 ± 0.1	6.4 ± 0.2	7.21 ^d
T_4	8.0 ± 0.1	7.8 ± 0.1	7.4 ± 0.2	7.6 ± 0.1	7.40 ^c
T_5	8.3 ± 0.1	8.4 ± 0.1	7.9 ± 0.1	7.6 ± 0.1	8.05 ^a
Mean	9.18 ^a	9.10 ^b	8.58 ^c	8.16 ^d	

T_0 = control; T_1 = mayonnaise containing 0.01% butylated hydroxy toluene (BHT); T_2 = mayonnaise containing 10% musk melon seed oil; T_3 = mayonnaise containing 20% musk melon seed oil; T_4 = mayonnaise containing 30% musk melon seed oil; T_5 = mayonnaise containing 40% musk melon seed oil; N = 2; data are shown as mean value ± standard deviation (SD).

period, oxidation started and minimized the quality and overall acceptability of the product. The overall acceptability changed due to changes in taste, color, appearance, and flavor. Extract of musk melon seeds added in mayonnaise showed considerable lowering of oxidation. Hence, the natural antioxidant plays an important role in controlling the oxidation process (Altunkaya *et al.*, 2013).

Conclusions

By comparing the effect of these antioxidants on the shelf life of the mayonnaise enhanced sensory quality and with 10, 20, 30, and 40% musk melon seed oil were stored at 25°C temperature for 10, 20, 40, and 60 days and evaluated by using different activity test viz. Results indicated that seed oil was more significant for antioxidant and antimicrobial activities, and lower the rate of free radicals, compared to the control synthetic sample. This recommends that musk melon seed oil must be used in a variety of economical food products, rather than discarded it as a waste. This would significantly lower the waste, with positive effects on economy of the country. This would also result in improved shelf life of food commodities and good health of consumers.

Availability of Data and Materials

Data can be provided on demand.

Conflict of Interest

The authors declared no conflict of interest and gave their consent for publishing of the article.

Author Contributions

Conceptualization (Zahra Nishat); Data curation (Sayyada Sana Mahmood); Formal analysis and Methodology (Zahra Nishat); Project Administration (Muhammad Yousaf Quddoos, Kashif Ameer, Isam A. Mohamed Ahmed, Moneera O. Aljobair); Journal Format Setting and Uploading to Journal (Muhammad Yousaf Quddoos and Ayesha Rafique); Resources (Shanza Mukhtar, Kashif Ameer, Isam A. Mohamed Ahmed, Moneera O. Aljobair); Software (Muhammad Siddique Raza, Aymen Shahzad); Supervision (Muhammad Yousaf Quddoos, Shahid Mahmood, Kashif Ameer); Validation (Kashif Ameer, Isam A. Mohamed Ahmed, Moneera O. Aljobair); Visualization (Bushra Umar Hayat, Neelum Shahzadi); Writing original draft (Zahra Nishat); Review & editing (Kashif Ameer, Muhammad Yousaf Quddoos).

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References

- Abdulkarim S.M., Long K, Lai O.M., Muhammad S.K.S. and Ghazali H.M. 2005. Some physico-chemical properties of *Moringa oleifera* seed oil extracted using solvent and aqueous enzymatic methods. Food Chem. 93:253–263. <https://doi.org/10.1016/j.foodchem.2004.09.023>
- Altunkaya A., Hedegaard R.V., Harholt J., Brimer L., Gökmen V. and Skibsted L.H. 2013. Oxidative stability and chemical safety of mayonnaise enriched with grape seed extract. Food Funct. 4:1647–1653. <https://doi.org/10.1039/c3fo60204d>
- American Association of Cereal Chemists (AACC). 2000. Approved Methods of American Association of Cereal Chemists, 10th ed. AACC, St. Paul, MN.
- American Oil Chemist's Society (AOCS). 2006. Official Methods and Recommended Practices of the AOCS, 5th ed. AOCS, Campaign, IL.
- Anwar F., Bhanger M. and Kazi T. 2003. Relationship between a raincoat and active oxygen method values at varying temperatures for several oils and fats. J Am Oil Chem Soc. 80:151–155. <https://doi.org/10.1007/s11746-003-0668-2>
- Ariizumi M., Kubo M., Handa A., Hayakawa T., Matsumiya K. and Matsumura Y. 2017. Influence of processing factors on the stability of model mayonnaise with whole egg during long-term storage. Biosci Biotechnol Biochem. 81:803–811. <https://doi.org/10.1080/09168451.2017.1281725>
- Association of Official Analytical Chemists (AOAC). 2006. Official Methods of Analysis, 17th ed. AOAC, Washington, DC.
- Azhari S., Xu Y., Jiang Q. and Xia W. 2014. Physicochemical properties and chemical composition of Seinat (*Cucumis melo* var. tibish) seed oil and its antioxidant activity. Grasas y Aceites. 65:008. <https://doi.org/10.3989/gya.074913>
- Chien Y.-H. 2015. Shelf Life Extension of Seed Butter Made with Sesame, Sunflower, and Pumpkin Seeds. Ohio State University, OH.
- Food and Agriculture Organization of United Nations (FAO). 2019. Food and Agriculture Data. FAO, Rome, Italy.
- Gaikwad M., Rathod B., Pawase P. and Kukade A. 2019. Studies on rheological properties of flavored mayonnaise.
- Government of Pakistan (GOP). 2015–2016. Fruit, Vegetables and Condiments Statistics of Pakistan. Ministry of National Food Security & Research Economic Wing, Government of Pakistan, Islamabad, Pakistan.
- Hussain S.A., Hameed A., Ajmal I., Nosheen S., Suleria H.a.R. and Song Y. 2018. Effects of sesame seed extract as a natural antioxidant on the oxidative stability of sunflower oil. J Food Sci Technol. 55:4099–4110. <https://doi.org/10.1007/s13197-018-3336-2>

- Ibrahim M. and El-Masry H. 2016. Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo* var. *cantalupensis*) and food application. *Int J Nutr Food Sci.* 5:16–24. <https://doi.org/10.11648/j.ijnfs.20160501.13>
- Ismail H.I., Chan K.W., Mariod A.A. and Ismail M. 2010. Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo*) methanolic extracts. *Food Chem.* 119:643–647. <https://doi.org/10.1016/j.foodchem.2009.07.023>
- Kaphueakngam P., Flood A. and Sonwai S. 2009. Production of cocoa butter equivalent from mango kernels almond fat and olive oil mid-fraction. *J Food Agricul Ind.* 2:441–447.
- Lalas S. and Tsakins J. 2002. Extraction and identification of natural antioxidants from the seeds of the *Moringa oleifera* tree variety of Malawi. *J Oil Chem.* 79:677–683. <https://doi.org/10.1007/s11746-002-0542-2>
- Landrault N., Poucheret P., Ravel P., et al. 2001. Antioxidant Capacities and Phenolics Levels of French Wines from Different Varieties and Vintages. *J. Agric. Food Chem.* 49(7):3341–3348. <https://doi.org/10.1021/jf010128f>
- Ma Z. and Boye J.I. 2013. Advances in the design and production of reduced-fat and reduced-cholesterol salad dressing and mayonnaise: a review. *Food Bioproc Technol.* 6:648–670. <https://doi.org/10.1007/s11947-012-1000-9>
- Mallek-Ayadi S., Bahloul N. and Kechaou N. 2018. Chemical composition and bioactive compounds of *Cucumis melo* L. seeds: potential source for new trends of plant oils. *Proc Safety Environ Prot.* 113:68–77. <https://doi.org/10.1016/j.psep.2017.09.016>
- Mansouri A., Mizrabe A.H. and Raufi A. 2017. Physical properties and mathematical modeling of melon (*Cucumis melo* L.) seeds and kernels. *J Saudi Soc Agricul Sci.* 16:218–226. <https://doi.org/10.1016/j.jssas.2015.07.001>
- Maran P.J. and Priya B. 2015. Supercritical fluid extraction of oil from muskmelon (*Cucumis melo*) seeds. *J Taiwan Inst Chem Eng.* 47:71–78. <https://doi.org/10.1016/j.jtice.2014.10.007>
- Mehra M., Pasricha V. and Gupta R.K. 2015. Estimation of nutritional, phytochemical, and antioxidant activity of seeds of musk melon (*Cucumis melo*) and watermelon (*Citrullus lanatus*) and nutritional analysis of their respective oils. *J Pharmacog Phytochem.* 3:98–102.
- Meilgaard D., Civille G.V. and Carr B.T. 2007. Sensory Evaluation Techniques, 4th ed. C.R.C Press, New York, NY. <https://doi.org/10.1201/b16452>
- Milind P. and Kulwant S. 2011. A review: musk melon is eat must-melon. *Int Res J Pharmacol.* 2:52–57.
- Mirzanajafi-Zanjani M., Yousefi M. and Ehsani A. 2019. Challenges and approaches for the production of a healthy and functional mayonnaise sauce. *Food Sci Nutr.* 7:2471–2484. <https://doi.org/10.1002/fsn3.1132>
- Montgomery D.C. 2008. Design and Analysis of Experiment, 7th ed. John Wiley, Hoboken, NJ, pp. 162–264.
- Mozafari H., Hosseini E., Hojjatoleslami M., Mohebbi G.H. and Jannati N. 2017. Optimization of low-fat and low-cholesterol mayonnaise production by central composite design. *J Food Sci Technol.* 54:591–600. <https://doi.org/10.1007/s13197-016-2436-0>
- Petkova Z. and Antova G. 2015. Proximate composition of seeds and seed oils from melon (*Cucumis melo* L.) cultivated in Bulgaria. *Cogent Food Agricul.* 1:1018779. <https://doi.org/10.1080/23311932.2015.1018779>
- Rashid U., Rehman H.A., Hussain I., Ibrahim M. and Haider M.S. 2011. Musk melon (*Cucumis melo*) seed oil: a potential non-food oil source for biodiesel production. *J Energy.* 36:5632–5639. <https://doi.org/10.1016/j.energy.2011.07.004>
- Shafi U., Mumtaz R., García-Nieto J., et al., 2019. Precision Agriculture Techniques and Practices: From Considerations to Applications. *Sensors.* 19(17):3796. <https://doi.org/10.3390/s19173796>
- Singla N., Verma P., Ghoshal G. and Basu S. 2013. Steady-state and time-dependent rheological behavior of mayonnaise (egg and eggless). *Int Food Res J.* 20:2009.
- Sun T. and Ho C. 2005. Antioxidant activities of buckwheat extracts. *Food Chem.* 90:743–749. <https://doi.org/10.1016/j.foodchem.2004.04.035>
- Yanty N.A.M., LAF O.M., Osman A., Long K. and Ghazali H. M. 2008. Physicochemical properties of *Cucumis melo* Var. *Indorus* (honeydew melon) seed and seed oil. *J Food Lipids.* 15:42–55. <https://doi.org/10.1111/j.1745-4522.2007.00101.x>
- Zeb A, Ullah F. 2016. A Simple Spectrophotometric Method for the Determination of Thiobarbituric Acid Reactive Substances in Fried Fast Foods. *J Anal Methods Chem.* 9412767. <https://doi.org/10.1155/2016/9412767>. Epub 2016 Mar 31.