



Egyptian Journal of Chemistry

<http://ejchem.journals.ekb.eg/>



Chemical quality of sponge cake supplemented with moringa seeds oil

Ahmed Mohamed Saied Hussein^{1*}, El-Kalyoubi M. H.², Ibrahim M.F. Helmy¹, Mohamed Khallaf², Ahmed R. Khalaf¹

¹Food Technology Department, National Research Centre, Dokki, Giza, Egypt,

²Food Science Department, Faculty of Agriculture, Ain Shams University



Abstract

In this study, oil from moringa seeds (*Moringa oleifera lam*) was substituted by cake shortening at various quantities (20, 40, 60, 80, and 100%). It was studied how this supplementation affected the cake's chemical composition, color characteristics, baking quality, chemical quality attributes (Acid value, Peroxide value and Thiobarbituric acid), organoleptic assessment, stalling rate, and texture profile analysis. These findings showed that the various enriched cake samples had higher levels of moisture, oil, and carbs than the control sample. L (lightness), a (redness), and b (yellowness) values dropped as the storage duration increased from 0 to 15 days, according to the results of the crust color evaluation. Additionally, during the storage period, the supplemented cake samples' crumb color L and b values dropped in comparison to the control, while the opposite pattern was seen for the a (redness) color values. All amounts of Moringa seed oil was added to the mixtures of cakes; cake samples supplemented with 60, 80, and 100% Moringa seed oil exhibited greater weight values than the control during storage. At various storage times, the volume values of the cake supplemented with oil from Moringa seeds at all levels were noticeably less than those of the control. During storage, the moisture contents of cakes with all supplementation amounts were greater than the control. The acid and peroxide levels of the various enhanced cakes did not change significantly ($p < 0.05$) during the course of the storage periods. TBA readings were significantly affected by any of the prepared supplemented cakes ($p < 0.05$), with the exception of 20%, which had the lowest levels at zero time and five days (43.79 and 46.81 mg malonaldehyde/kg). The cake with 100% Moringa seed oil added obtained the best ratings for overall acceptance and all identified sensory characteristics. Cake's alkaline water retention capacity (AWRC) values were lowered during storage times when varying amounts of Moringa seed oil were added. The gumminess and hardness values of all the treated cakes were greater than those of the control samples, according to the texture profile analysis.

Keywords: Sponge cake, moringa seeds oil, chemical composition, color, baking quality, sensory characteristics

1. Introduction

Excessive calorie consumption and inadequate dietary fiber intake are contributing to the rise of nutrition-related disorders. As a result, the number of people who are overweight or obese has doubled during the past 30 years [1]. Other non-communicable illnesses may be linked to obesity [2]. Since fat has the highest energy value of all the main dietary elements, it might be difficult to replace fat with other ingredients, particularly in baked goods that may include high fat content [3]. In bakery products, fat improve texture, mouth feel and flavour [4]. Additionally, fat gives cakes a number of benefits, including increased volume and softness in the finished product. Cake, whether homemade or commercially created, is regarded as one of the most significant bakery goods for Egyptians [5].

The species and environmental factors mostly determine the oil's composition and characteristics [6]. The bright yellow oil extracted from *Moringa oleifera* seed kernels has a high oleic acid content (about 75%) [7, 8]. Unlike polyunsaturated fatty acids, oleic acid has significant oxidative stability, making it indispensable for high-temperature frying and extended storage [7]. The oil has a variety of applications, including cosmetics [9], medicine, and new research indicates that *Moringa oleifera* may be used to produce biodiesel [10].

The level of lipids in *M. oleifera* seeds was reported between 14% and 46% dwb [11, 12]. The lipids are low in monounsaturated and saturated fatty acids but higher in polyunsaturated fatty acids representing up to 75%–79% [12]. However, the oil is a source of some minor compounds (phytosterols and tocopherols). Several studies investigated the role of *M. oleifera* seed oil in human nutrition, and this includes physicochemical characteristics of the oil and its biological value [13–16]. The functional compounds in moringa seed oil consist of 82% unsaturated fatty acids, 70% oleic acid [17]. *Moringa oleifera* seed oil is one of the most important natural alternatives as it contains tocopherol, phenols, carotenoids and sterols [18–20]. In addition to the high content of oleic acid, this is important for extending the shelf life of oils and increasing their stability [21].

Sponge cake has a porous structure like a sponge and is lightweight and soft. The sponge cake making involves ingredients such as flour, fat source, water and other minor ingredients like salt. This type of cake is traditionally produced by the multistage mixing method which is time consuming. The single-stage mixing method has been developed and widely practiced in the large-scale production of sponge cakes. To produce foam with a good texture, sponge cake formulations generally use an additional emulsifying agent to form better aeration [22]. Therefore, this study was carried out to investigate the effect of supplementation with different levels of moringa seeds oil on the physical, chemical, and organoleptic characteristics to improve the quality of sponge cake.

2- Materials and Methods

Moringa seeds (*Moringa oleifera lam*) were obtained from National Research Center (NRC), Horticultural Department, Dokki, Giza, Egypt. Wheat flour (72%) was obtained from South Cairo Mill Company, Giza, Egypt. Sugar, salt (sodium chloride), shortening, salt, baking powder and vanilla were purchased from the local market, Giza, Egypt.

*Corresponding author e-mail a_said22220@yahoo.com

Received Date: 18 June 2025, Revised Date: 04 August 2025, Accepted Date: 17 August 2025

DOI: 10.21608/EJCHEM.2025.395741.11924

©2026 National Information and Documentation Center (NIDOC)

Oil Extraction

The dried seeds were crushed in a knife mill to obtain homogenous seed particles. Subsequently, the crushed seeds were mechanically pressed to extract the edible oil then filtered and kept in dark bottles with airtight lids under cooling temperature until being used [23].

Preparation of sponge cakes

Sponge cake was prepared according to Bennion and Pamford [22] with some modifications as follows: Flour (100gm) and baking powder (3gm) were mixed together; whole fresh eggs (125gm), sugar (75gm), skimmed milk (50gm), shortening (28gm) and vanilla (2gm) were whipped for 6 min. with using a mixer at high speed. Flour mixture was added gradually on the whipped milk-vanilla mixture and beaten for three min. using the mixer at low speed. One hundred gram of dough were poured in baking pans, then placed in a preheated oven and baked at 180°C for 35 min. Cakes were allowed to cool for 30 min. in pans at room temperature. Moringa seeds oil was utilized to prepare cake as replacement of shortening at different levels (20, 40, 60, 80 and 100% moringa oil).

Analytical methods

Chemical composition

Moisture, protein, Fat, ash and crude fiber contents were determined according to AOAC [24]. Carbohydrates were calculated by difference.

Color measurements

The color of produced cake samples were measured using a Spectro-Colorimeter (Tristimulus color machine) with CIE lab color scale (Hunter, Lab Scan XE, Reston VA.) calibrated with a white standard tile of Hunter Lab color standard (LXNO. 16379): X= 77.26, Y= 81.94 and Z= 88.14 [25].

Chemical parameters of extracted oil

Acid value, peroxide value and Thiobarbituric acid were determined according to AOAC [24].

Physical measurements of sponge cake

Weight, volume and specific volume of cakes were determined as described in AACC [26].

Texture properties of cake

Texture parameters (hardness, springiness, cohesiveness, gumminess and chewiness) of cake samples were measured objectively by using a Texture Analyzer TA-CT3 (Brookfield, USA) according to AACC [26].

Freshness of cake

Freshness of cake samples was tested at refrigerator temperature (4°C) during storage for 0, 5, 10 and 15 days by alkaline water retention capacity (AWRC) according to method of Yamazaki [27] as modified by Kitterman and Rubenthaler [28].

Organoleptic evaluation of cakes

Cakes were assessed by 15 panelists for some sensory parameters (color (20), taste (20), odor (20), texture (20), appearance (20) and overall acceptability (100) as described by Bodyfelt *et al* [29].

Statistical Analysis

All the measurements were performed in triplicate and the data are presented as mean $\pm$ SD. The obtained data were subjected to analysis of variance. Duncan [30] multiple ranges at 5% level of significance used to compare between means. The analysis was carried out using the proc- ANOVA procedure according to PC-STAT, Version I A Copyright 1985, the university of Georgia, USA.

3. Results and Discussion

Chemical composition of cake

The chemical makeup of cake supplemented with varying amounts of moringa oil is displayed in Table (1). Both the control sample and the various cake samples supplemented with 20, 40, 60, 80, and 100% moringa oil showed a shift in moisture content from 22.28 to 30.33%. Several cake samples exhibited higher moisture contents than cakes reported by Eman [31] and Abd Elhadi and Nadir [32], who examined the cake's chemical makeup and discovered that it contained 18.6 and 21.01%, respectively. However, there were no appreciable variations ($p < 0.05$) in the protein content between the prepared cake samples and the control sample. According to Shokery *et al.* [33], the protein composition of the cake was unaffected when extracted Moringa oil (MO) was used in place of shortening. The oil content of the control sample and the various supplementation percentages (20, 40, 60, 80, and 100%) were, respectively, 25.84, 28.26, 28.05, 29.42, 31.14, and 31.45 percent, according to the data in Table (1). All treatments had higher oil contents than the control cake's oil %. The significant increase in moringa oil may be due to the high emulsifying capacity of moringa oil, as reported by Abdelraouf *et al.* [34]. Furthermore, shortening contains a moisture content of up to 20%, which contributes to the significant differences. At the same time, it could be said that the made cake samples had ash contents ranging from 2.75 to 3.69%. Ash is significantly greater than that observed in control cake. The fiber and carbohydrate levels in several cake samples ranged from 0.27 to 0.47 and 45.70 to 51.88%, respectively. The prepared cake samples' total carbohydrate content was determined to be 50.36%, which is consistent with the findings of Al-sayed and Abo_Elfetoh [35].

Color attributes for crust and crumb of cake

Table (2)'s color assessment showed that 20, 40, 60, 80, and 100% moringa oil had a significant ($P < 0.05$) impact on the Hunter color parameters values of every made cake sample's crust. Over the course of the storage period, the control sample's lightness (L^*) and a^* (redness) values declined, but the b^* (yellowness) color values showed the opposite trend. Cake samples supplemented with moringa oil had an impact on the color parameters values during the course of the storage period; at the fifteenth.

Table 1: Chemical composition of cake supplemented with moringa oil at different levels (on dry weight basis)

Samples	Moisture %	Protein %	Oil %	Ash %	Fiber%	Carbohydrate %
Control	22.28 ^c ±0.37	18.86 ^a ±0.11	25.84 ^d ±0.31	3.01 ^{bc} ±0.09	0.41 ^{ab} ±0.02	51.88 ^a ±0.031
20% MO	26.45 ^b ±1.84	18.85 ^a ±0.58	28.26 ^{bcd} ±0.47	3.33 ^{ab} ±0.08	0.27 ^c ±0.02	49.29 ^{abc} ±1.11
40% MO	23.99 ^{bc} ±1.02	17.82 ^a ±0.64	28.05 ^{cd} ±0.85	3.14 ^{abc} ±0.31	0.33 ^{bc} ±0.02	50.66 ^{ab} ±3.54
60% MO	26.56 ^{ab} ±0.83	18.65 ^a ±0.86	29.42 ^{abc} ±1.09	3.69 ^a ±0.08	0.29 ^c ±0.03	47.95 ^{bc} ±1.91
80% MO	27.36 ^{ab} ±0.60	19.39 ^a ±0.37	31.14 ^{ab} ±0.22	2.75 ^c ±0.02	0.47 ^a ±0.01	46.25 ^{bc} ±0.65
100% MO	30.33 ^a ±0.18	19.49 ^a ±0.30	31.45 ^a ±0.97	3.07 ^{bc} ±0.02	0.29 ^c ±0.03	45.70 ^c ±1.23
L.S.D at 0.05	3.87	2.13	2.92	0.56	0.09	7.16

Where: MO: moringa oil; Values are means ± standard deviation of triplicate determinations, Means in the same row not followed by the same superscript letters are significantly ($p \leq 0.05$) different.

Table 2: Color attributes of cake crust Supplemented with moringa oil during the storage periods at different levels

Samples crust	L*	a*	b*	L*	a*	b*
	zero time			After 5 days		
Control	60.06 ^{aA} ±0.40	12.64 ^{aA} ±0.08	34.34 ^{aA} ±0.18	57.29 ^{ab} ±0.01	12.10 ^{dB} ±0.01	34.94 ^{aA} ±0.01
20% MO	45.25 ^{cdC} ±0.14	17.20 ^{bA} ±0.05	30.67 ^{cB} ±0.06	48.52 ^{cB} ±0.00	16.62 ^{cB} ±0.02	33.01 ^{bA} ±0.02
40% MO	45.77 ^{CA} ±1.18	17.56 ^{bA} ±0.08	32.43 ^{bA} ±0.19	44.44 ^{dB} ±0.04	17.01 ^{bcB} ±0.04	30.05 ^{cB} ±0.21
60% MO	44.23 ^{dA} ±0.84	17.46 ^{bA} ±0.34	29.38 ^{dA} ±0.33	42.47 ^{eB} ±0.53	17.06 ^{BB} ±0.05	27.75 ^{dB} ±0.08
80% MO	50.79 ^{bAB} ±0.40	19.02 ^{aA} ±0.00	35.45 ^{aA} ±0.21	51.66 ^{bA} ±0.36	17.67 ^{aC} ±0.16	35.37 ^{aA} ±0.30
100% MO	44.50 ^{cdA} ±0.08	17.55 ^{bA} ±0.04	32.59 ^{bA} ±0.21	41.66 ^{eB} ±0.01	16.84 ^{bcB} ±0.01	29.22 ^{cC} ±0.04
	After 10 days			After 15 days		
Control	53.29 ^{aC} ±0.03	12.74 ^{dA} ±0.04	35.31 ^{aA} ±0.01	53.57 ^{aC} ±0.01	12.45 ^{dAB} ±0.01	34.45 ^{bA} ±0.01
20% MO	49.34 ^{bAB} ±0.38	15.60 ^{cC} ±0.00	33.27 ^{bA} ±0.19	50.04 ^{aC} ±0.66	15.22 ^{CD} ±0.08	32.58 ^{aC} ±0.30
40% MO	41.18 ^{cd} ±0.06	16.58 ^{bC} ±0.11	28.90 ^{cC} ±0.12	42.44 ^{dC} ±0.37	16.46 ^{bC} ±0.04	29.02 ^{eBC} ±0.22
60% MO	42.08 ^{cB} ±0.04	16.58 ^{bC} ±0.02	29.30 ^{aC} ±0.02	42.65 ^{dB} ±0.07	16.39 ^{bC} ±0.05	27.70 ^{FB} ±0.11
80% MO	49.80 ^{bb} ±0.08	18.37 ^{aB} ±0.01	35.13 ^{aA} ±0.13	51.83 ^{bA} ±0.01	17.35 ^{aC} ±0.21	35.77 ^{aA} ±0.37
100% MO	42.24 ^{cB} ±0.29	16.76 ^{bB} ±0.01	30.06 ^{BC} ±0.00	39.94 ^{cC} ±0.99	16.73 ^{BB} ±0.44	31.01 ^{dB} ±1.82

Where: MO: moringa oil; L*= lightness; a*= redness and b*= yellowness; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$)

Table 3: Color attributes of cake crumb supplemented with moringa oil during the storage periods at different levels

Samples crumb	L*	a*	b*	L*	a*	b*
	zero time			After 5 days		
Control	57.86 ^{cc} ±0.40	7.03 ^{CA} ±0.13	35.84 ^{ab} ±0.02	63.70 ^{aA} ±0.11	6.29 ^{CC} ±0.04	35.09 ^{ac} ±0.07
20% MO	54.34 ^{dc} ±0.01	7.15 ^{bcB} ±0.01	30.85 ^{ed} ±0.01	57.16 ^{dB} ±0.04	7.28 ^{ab} ±0.01	31.25 ^{ec} ±0.04
40% MO	57.78 ^{cb} ±0.83	7.36 ^{abB} ±0.04	34.14 ^{cB} ±0.24	58.75 ^{cAB} ±0.11	7.20 ^{ab} ±0.00	33.51 ^{CC} ±0.01
60% MO	58.11 ^{CA} ±0.10	7.57 ^{ab} ±0.04	34.89 ^{bb} ±0.09	58.35 ^{CA} ±0.04	7.30 ^{aC} ±0.01	34.21 ^{bC} ±0.04
80% MO	63.50 ^{aA} ±0.04	5.20 ^{dC} ±0.06	32.98 ^{dC} ±0.06	60.84 ^{bB} ±0.59	6.40 ^{bcB} ±0.01	33.05 ^{dC} ±0.13
100% MO	59.65 ^{bB} ±0.18	6.92 ^{cC} ±0.05	35.51 ^{aB} ±0.10	61.05 ^{bA} ±0.06	6.68 ^{bC} ±0.03	34.81 ^{aC} ±0.07
	After 10 days			After 15 days		
Control	62.21 ^{ab} ±0.02	6.64 ^{dB} ±0.04	37.97 ^{aA} ±0.04	62.46 ^{ab} ±0.04	7.19 ^{bA} ±0.00	37.98 ^{aA} ±0.05
20% MO	57.26 ^{bb} ±0.11	7.66 ^{CA} ±0.01	34.00 ^{eA} ±0.08	59.65 ^{bA} ±0.90	6.79 ^{cC} ±0.19	31.70 ^{eb} ±0.27
40% MO	56.13 ^{cC} ±0.33	8.51 ^{bA} ±0.21	35.96 ^{bCA} ±0.16	59.23 ^{bA} ±0.72	7.20 ^{bb} ±0.15	34.06 ^{dB} ±0.10
60% MO	52.67 ^{eb} ±0.05	9.16 ^{aA} ±0.05	35.72 ^{bCA} ±0.08	57.61 ^{CA} ±0.05	7.60 ^{ab} ±0.04	34.83 ^{cB} ±0.18
80% MO	58.29 ^{bc} ±0.30	7.39 ^{CA} ±0.13	35.17 ^{dA} ±0.09	62.79 ^{aA} ±0.37	6.32 ^{dB} ±0.16	33.70 ^{dB} ±0.23
100% MO	54.49 ^{dC} ±0.04	8.59 ^{bA} ±0.11	36.25 ^{aB} ±0.29	58.96 ^{bB} ±0.48	7.48 ^{ab} ±0.11	35.79 ^{bB} ±0.12

Where: MO: moringa oil; L*= lightness; a*= redness and b*= yellowness; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$). day of storage, the lightness (L*) values reduced to range between 42.44 and 50.83. In the meantime, the * (redness) values rose in comparison to the control and fell during the course of storage. The range of the decline was 15.22 to 17.35. Additionally, the yellowness, or b*, was lower than the control. As the storage duration increased from day 0 to day 15, L*, a*, and b* typically

decreased. Regarding the crumb color characteristics displayed in Table (3), the supplementation cake samples containing moringa oil showed a drop in Lightness (L^*) and b^* (Yellowness) values as compared to the control sample throughout the course of storage. The opposite trend was seen for a^* (redness) color values. Values for color parameters changed during the course of storage; for example, lightness (L^*) values rose on the fifteenth day. In contrast, values were lowest throughout other storage periods, whereas a^* (redness) and b^* (yellowness) values peaked on the tenth day of storage.

Baking quality of cake

Table 4 lists the baking quality of cakes replacement with varying amounts of moringa oil at various storage times. The table's findings showed that cake samples supplemented with varying amounts of moringa oil throughout storage periods (0, 5, 10, and 15 days) had weight values that were greater than the control for cake samples supplied with 60%, 80%, and 100% moringa oil. At various storage times, the weight values of cakes supplemented with 20% and 40% moringa oil were lower than those of the control. Cakes held for zero time had the largest decrease in weight values of the final samples. Cakes supplemented with 60%, 80%, and 100% moringa oil and cakes supplemented with 20% and 40% moringa oil at varying storage times showed rising and decreasing rates ranging from 1.22 to 3.48% and 4.12 to 6.94%, respectively. The weight of the various cakes supplemented with 20, 40, 60, 80, and 100% moringa oil did not change significantly ($p \leq 0.05$) during the course of the storage days. These findings are consistent with those of Shokery *et al.* [33], who found that the weight of cake samples containing MO increased and decreased in relation to the control sample. Additionally, the same table demonstrated that at various storage times, the volume values of cakes supplemented with varying concentrations of moringa oil were much lower than those of the control. Cakes supplemented with various supplementation percentages at zero time storage had the lowest drop in volume values, whereas cakes stored under the same conditions for the last 15 days had the biggest reduction in the same parameter. The same samples' specific volume values exhibited a similar pattern, being considerably lower at zero time and after five, ten, and fifteen storage days, respectively, although not significantly lower than the control. It varied between 3.86 and 15.88% at zero time, 4.37 and 15.72% after five days of storage, 6.10 and 17.84% after ten days, and 8.97 and 20.79% after fifteen days.

Table 4: baking quality of cake with different levels of moringa oil at different storage periods at 25°C for 15 days

Samples	Weight (g)	Volume (cm ³)	Specific volume (cm ³ /g)	Weight (g)	Volume (cm ³)	Specific volume (cm ³ /g)
	zero time			After 5 days		
Control	122.50 ^{bA} ±2.12	285.50 ^{aA} ±0.71	2.33 ^{aA} ±0.03	123.72 ^{bA} ±0.34	283.20 ^{aA} ±1.13	2.29 ^{aA} ±0.20
20% MO	117.00 ^{cA} ±1.41	250.50 ^{cdA} ±3.54	2.14 ^{aA} ±0.03	118.38 ^{cA} ±0.24	249.16 ^{CA} ±1.84	2.10 ^{aA} ±0.18
40% MO	114.00 ^{cA} ±1.41	255.00 ^{cA} ±1.70	2.24 ^{aA} ±0.08	115.41 ^{cA} ±0.65	252.53 ^{CA} ±0.37	2.19 ^{aA} ±0.23
60% MO	126.50 ^{aA} ±2.12	274.50 ^{bA} ±1.13	2.17 ^{aA} ±0.06	127.83 ^{aA} ±1.07	272.91 ^{bA} ±1.17	2.13 ^{aA} ±0.40
80% MO	126.00 ^{abA} ±2.83	246.50 ^{dA} ±4.95	1.96 ^{aA} ±0.04	126.62 ^{abA} ±0.49	243.84 ^{dA} ±0.40	1.93 ^{aA} ±0.17
100% MO	124.00 ^{abB} ±1.41	278.00 ^{bA} ±0.71	2.24 ^{aA} ±0.03	125.47 ^{abAB} ±0.82	275.28 ^{bA} ±0.68	2.19 ^{aA} ±0.34
	After 10 days			After 15 days		
Control	124.40 ^{bA} ±1.17	264.97 ^{aB} ±2.63	2.13 ^{aA} ±0.28	125.37 ^{bA} ±1.05	253.24 ^{aC} ±1.29	2.02 ^{aA} ±0.07
20% MO	119.28 ^{cA} ±1.37	223.05 ^{eb} ±1.56	1.87 ^{aA} ±0.16	120.19 ^{cA} ±0.35	198.31 ^{eC} ±1.00	1.65 ^{aA} ±0.08
40% MO	116.60 ^{cA} ±1.51	230.86 ^{dB} ±1.71	1.98 ^{aA} ±0.18	117.43 ^{cA} ±0.62	213.72 ^{cC} ±0.79	1.82 ^{aA} ±0.28
60% MO	128.73 ^{aA} ±0.75	245.87 ^{cB} ±0.51	1.91 ^{aA} ±0.13	129.68 ^{aA} ±0.66	232.12 ^{bC} ±1.05	1.79 ^{aA} ±0.11
80% MO	127.51 ^{abA} ±0.93	229.51 ^{dB} ±1.13	1.80 ^{aA} ±0.24	128.70 ^{abA} ±0.81	205.92 ^{dC} ±1.15	1.60 ^{aA} ±0.18
100% MO	126.39 ^{abAB} ±1.71	252.78 ^{bB} ±0.78	2.00 ^{aA} ±0.07	127.59 ^{abAB} ±0.72	234.76 ^{bC} ±0.58	1.84 ^{aA} ±0.21

Where: MO: moringa oil; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$)

Moisture and oil contents of cake

Table 5 shows the moisture and oil content of cake that has been supplemented with moringa oil at varying quantities during storage times. The findings demonstrated that while there was no significant ($p \leq 0.05$) change in the oil content of the various supplemented cakes with 20, 40, 60, 80, and 100% moringa oil over storage periods, all supplementation levels for cake samples with moringa oil tended to increase their moisture contents. Generally speaking, as the amount of moringa oil supplementation rose, so did the moisture content of all supplemented cake samples throughout all storage durations. At zero time, the moisture level of the various enhanced cake samples was at its lowest. Samples that had been stored for 15 days had the greatest and lowest moisture and oil content values.

Chemical quality attributes of oil extract from cake supplement with moringa oil

Table 6 displays the findings for the cake samples' acid value (AV), peroxide value (PV), and thiobarbituric acid (TBA) after they were kept at room temperature for 15 days. There was no significant ($p \leq 0.05$) in acid levels of the varied supplemented cake with 20, 40, 60, 80 and 100% moringa oil, similarly comparable result was seen over the storage periods. PV, which quantifies lipid peroxide and hydroperoxides produced during the early stages of oxidation, is most commonly employed as an indication of fat oxidation. Values are expressed as milli-equivalent of peroxide per kilogram of fat [36]. The

peroxide values of the various cakes added with 20, 40, 60, 80, and 100% moringa oil did not change significantly ($p \leq 0.05$). The control sample, however, showed a much greater PV than the enhanced cake after 15 days of storage. Conversely, when storage time increased, PV rose as well. This is consistent with Shokery *et al.* [33], who reported that all prepared cup cake samples had an increase in PV at the end of storage periods. The control sample's oxidation rate was higher than that of the cup cake samples containing extracted MO, albeit by a different percentage. This could be because extracted MO contains a high amount of antioxidants. The PV of all prepared cake samples were below the critical values given by Robards *et al.* [37] who reported that, edible oil with PV of 7.5 meq. O₂/kg was deemed unacceptable from sensory point of view. Benade [38] mentioned that, the PV increase with time to a maximum level after which it decomposes rapidly to secondary products leading to a subsequent decrease in the PV. The result indicated that the decomposition of peroxides in the control cake occur at higher rate than the formulated cake. To assess the development of rancidity in the prepared cake samples during storage periods, the thiobarbituric acid values (TBA) was calculated. Table (6) showed that, all prepared cake samples supplemented with moringa oil at different levels (20, 40, 60, 80 and 100%) have no significant on TBA values except 20% was lowest at zero time and after 5 days (0.04 and 0.05 mg malonadhyde/kg), respectively. However, prepared cake samples treated with moringa oil at zero time, five days, and ten days.

Table 5: Moisture content and oil content of cake with moringa oil at different levels during storage periods

Samples	Moisture content	Oil content	Moisture content	Oil content
	zero time		After 5 days	
Control	22.28 ^{CB} ±0.37	25.84 ^{BA} ±0.31	24.70 ^{CA} ±0.22	25.06 ^{BA} ±0.34
20% MO	26.45 ^{BB} ±1.84	28.26 ^{AB} ±0.47	27.80 ^{BA} ±0.32	27.61 ^{AB} ±3.46
40% MO	23.99 ^{CB} ±1.02	28.05 ^{AB} ±0.85	25.09 ^{CB} ±1.36	27.33 ^{AB} ±2.61
60% MO	26.56 ^{BA} ±0.83	29.42 ^{AB} ±1.09	26.90 ^{BA} ±0.34	28.42 ^{AB} ±0.50
80% MO	27.36 ^{BA} ±0.60	31.14 ^{AA} ±0.22	28.18 ^{BA} ±1.36	30.65 ^{AA} ±0.15
100% MO	30.33 ^{AA} ±0.18	31.45 ^{AA} ±0.97	30.82 ^{AA} ±1.05	30.20 ^{AB} ±2.69
Samples	After 10 days		After 15 days	
Control	25.24 ^{CA} ±0.20	24.72 ^{BA} ±0.18	25.90 ^{CA} ±5.09	24.61 ^{BA} ±0.29
20% MO	28.82 ^{BCB} ±0.44	27.06 ^{AB} ±1.22	29.81 ^{AB} ±0.18	26.61 ^{AB} ±0.30
40% MO	27.73 ^{CB} ±0.28	26.90 ^{AB} ±0.78	29.32 ^{BA} ±0.10	26.84 ^{AB} ±1.31
60% MO	27.21 ^{BCA} ±0.61	28.22 ^{BA} ±0.02	28.04 ^{BCA} ±1.51	27.69 ^{AB} ±0.64
80% MO	28.79 ^{AB} ±0.76	30.27 ^{AA} ±0.00	29.04 ^{BA} ±1.10	29.45 ^{AA} ±0.45
100% MO	31.02 ^{AA} ±0.35	29.70 ^{AB} ±0.43	31.82 ^{AA} ±0.04	28.02 ^{AB} ±0.33

Where: MO: moringa oil; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$).

Table 6: Chemical quality attributes of cake with moringa oil during storage

Samples	AV*	PV*	TBA*	AV*	PV*	TBA*
	zero time			After 5 days		
Control	0.11 ^{AA} ±0.04	0.68 ^{AB} ±0.00	42.11 ^{BC} ±0.06	0.16 ^{AB} ±0.03	0.94 ^{AB} ±0.49	50.22 ^{BB} ±3.80
20% MO	0.11 ^{AA} ±0.04	0.69 ^{AC} ±0.15	43.79 ^{BB} ±0.03	0.20 ^{AA} ±0.02	1.06 ^{ABC} ±0.27	46.81 ^{BB} ±2.44
40% MO	0.11 ^{AA} ±0.00	0.54 ^{AB} ±0.08	56.01 ^{AB} ±0.27	0.16 ^{AB} ±0.04	1.33 ^{AA} ±0.21	60.99 ^{AB} ±4.44
60% MO	0.06 ^{AA} ±0.02	0.93 ^{AB} ±0.15	57.02 ^{AB} ±6.16	0.15 ^{AB} ±0.02	0.96 ^{AB} ±0.19	60.99 ^{AB} ±3.20
80% MO	0.15 ^{AA} ±0.06	0.94 ^{AB} ±0.19	56.44 ^{AB} ±6.65	0.17 ^{AB} ±0.01	0.91 ^{AB} ±0.20	60.61 ^{AB} ±1.04
100% MO	0.06 ^{AB} ±0.02	1.02 ^{AA} ±0.03	52.84 ^{AB} ±1.86	0.10 ^{AB} ±0.00	1.13 ^{AA} ±0.03	64.07 ^{AA} ±0.50
Samples	After 10 days			After 15 days		
Control	0.18 ^{AA} ±0.04	1.77 ^{AA} ±0.15	50.47 ^{BB} ±0.39	0.21 ^{AA} ±0.06	1.86 ^{AA} ±0.03	64.07 ^{AA} ±2.95
20% MO	0.20 ^{AA} ±0.03	1.49 ^{AB} ±0.04	60.74 ^{AA} ±1.67	0.21 ^{AA} ±0.02	1.81 ^{AA} ±0.11	65.42 ^{AA} ±2.26
40% MO	0.20 ^{AA} ±0.02	1.39 ^{AB} ±0.32	62.91 ^{AB} ±0.44	0.21 ^{AA} ±0.02	1.68 ^{AA} ±0.17	68.18 ^{AA} ±1.52
60% MO	0.15 ^{AA} ±0.04	1.20 ^{AB} ±0.13	62.60 ^{AB} ±0.99	0.18 ^{AA} ±0.06	1.66 ^{AA} ±0.14	70.61 ^{AA} ±0.69
80% MO	0.21 ^{AA} ±0.03	1.29 ^{AB} ±0.08	62.50 ^{AB} ±0.43	0.21 ^{AA} ±0.05	1.56 ^{AA} ±0.18	69.26 ^{AA} ±1.58
100% MO	0.11 ^{AB} ±0.00	1.25 ^{AB} ±0.11	66.87 ^{AA} ±3.47	0.15 ^{AA} ±0.03	1.47 ^{AA} ±0.03	69.73 ^{AA} ±1.63

Where: MO: moringa oil; AV= Acid value; PV= Peroxide value and TBA= Thiobarbituric acid; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$).

(0.04, 0.05, and 0.05 mg malonadhyde/kg) were higher than the control sample. It was evident from the same table that the TBA values of the prepared cake samples significantly increased with the length of storage. These findings concurred with those of Sharif *et al.* [39], who found that the TBA values of cookie samples containing rice bran oil increased over storage.

Organoleptic evaluation of cake:

Table (7) displays the findings for the sensory attributes (color, taste, odor, texture, appearance, and overall acceptance). To ascertain overall acceptability, the values of Color, Taste, Odor, Texture, and Appearance were assessed. The results showed that the sensory qualities of the cake samples made by using moringa oil for shortening did not change substantially ($p < 0.05$). However, the cake that had 80% moringa oil added to it had a high color value (16.67). On the other hand, the sample enhanced with 100% moringa oil had high levels of taste, odor, texture, and appearance. Conversely, the sample supplemented with 20% moringa oil had the same sensory qualities as the control sample at zero time. Regarding overall acceptability of cake made from wheat flour (72%) supplemented with 100% moringa oil had the highest scores (83.67),

Table 7: Organoleptic evaluation of cake with different levels of moringa oil during different storage periods.

Samples	Color (20)	Taste (20)	Odor (20)	Texture (20)	Appearance (20)	overall acceptability (100)
zero time						
Control	15.33 ^{aA} ±5.01	14.83 ^{aA} ±3.19	15.50 ^{aA} ±4.37	16.33 ^{aA} ±2.58	15.50 ^{aA} ±4.23	77.50
20% MO	13.50 ^{aA} ±3.27	13.00 ^{aA} ±3.69	12.83 ^{aA} ±3.82	12.83 ^{aA} ±4.54	14.33 ^{aA} ±3.50	66.50
40% MO	15.17 ^{aA} ±2.23	15.50 ^{aA} ±2.74	15.33 ^{aA} ±3.14	16.00 ^{aA} ±3.10	15.50 ^{aA} ±3.08	77.50
60% MO	15.67 ^{aA} ±1.51	15.33 ^{aA} ±2.73	15.50 ^{aA} ±2.74	16.33 ^{aA} ±2.73	16.17 ^{aA} ±2.64	79.00
80% MO	16.67 ^{aA} ±1.75	16.00 ^{aA} ±2.68	16.17 ^{aA} ±2.40	16.50 ^{aA} ±1.97	16.67 ^{aA} ±2.07	82.00
100% MO	16.33 ^{aA} ±1.75	16.50 ^{aA} ±2.17	16.83 ^{aA} ±1.72	17.17 ^{aA} ±2.14	16.83 ^{aA} ±1.94	83.67
After 5 days						
Control	15.19 ^{aA} ±1.33	14.26 ^{aA} ±2.25	15.18 ^{aA} ±3.42	16.10 ^{aA} ±1.81	15.20 ^{aA} ±2.31	75.93
20% MO	13.22 ^{aA} ±1.09	12.71 ^{aA} ±2.60	11.94 ^{aA} ±2.29	12.60 ^{aA} ±2.31	14.12 ^{aA} ±2.22	64.59
40% MO	15.07 ^{aA} ±1.47	14.80 ^{aA} ±3.78	14.75 ^{aA} ±3.35	15.84 ^{aA} ±2.59	15.14 ^{aA} ±2.69	75.60
60% MO	15.30 ^{aA} ±1.47	14.65 ^{aA} ±3.15	14.38 ^{aA} ±3.07	15.97 ^{aA} ±2.97	15.70 ^{aA} ±1.94	76.00
80% MO	16.20 ^{aA} ±1.37	15.56 ^{aA} ±2.02	15.60 ^{aA} ±2.60	16.03 ^{aA} ±1.61	15.83 ^{aA} ±3.07	79.22
100% MO	16.09 ^{aA} ±1.75	15.92 ^{aA} ±3.82	15.57 ^{aA} ±1.91	16.89 ^{aA} ±1.87	16.24 ^{aA} ±1.80	80.71
After 10 days						
Control	14.80 ^{aA} ±1.39	13.65 ^{aA} ±2.79	14.37 ^{aA} ±3.37	15.93 ^{aA} ±3.66	14.86 ^{aA} ±1.71	73.61
20% MO	12.95 ^{aA} ±2.73	11.73 ^{aA} ±2.57	10.69 ^{aA} ±3.52	12.25 ^{aA} ±2.38	13.89 ^{aA} ±2.19	61.51
40% MO	14.87 ^{aA} ±3.44	13.52 ^{aA} ±3.41	13.80 ^{aA} ±3.65	15.60 ^{aA} ±3.24	14.84 ^{aA} ±2.26	72.63
60% MO	15.05 ^{aA} ±2.56	13.49 ^{aA} ±2.02	13.72 ^{aA} ±2.67	15.54 ^{aA} ±1.71	15.31 ^{aA} ±2.81	73.11
80% MO	15.93 ^{aA} ±1.68	14.60 ^{aA} ±3.86	14.45 ^{aA} ±3.00	15.78 ^{aA} ±2.21	15.46 ^{aA} ±2.96	76.22
100% MO	15.79 ^{aA} ±2.63	14.84 ^{aA} ±3.38	14.74 ^{aA} ±2.33	16.62 ^{aA} ±1.80	15.77 ^{aA} ±1.78	77.76
After 15 days						
Control	14.21 ^{aA} ±2.08	12.43 ^{aA} ±2.72	13.64 ^{aA} ±2.22	15.25 ^{aA} ±2.02	14.23 ^{aA} ±1.65	69.76
20% MO	12.42 ^{aA} ±1.09	10.32 ^{aA} ±3.38	9.57 ^{aA} ±2.66	11.94 ^{aA} ±2.45	13.40 ^{aA} ±2.57	57.65
40% MO	14.50 ^{aA} ±2.74	12.29 ^{aA} ±2.57	12.18 ^{aA} ±2.98	15.26 ^{aA} ±2.62	14.39 ^{aA} ±2.14	68.62
60% MO	14.86 ^{aA} ±2.47	12.20 ^{aA} ±2.64	12.30 ^{aA} ±3.51	15.11 ^{aA} ±2.60	15.07 ^{aA} ±2.40	69.54
80% MO	15.60 ^{aA} ±2.15	13.23 ^{aA} ±2.18	13.17 ^{aA} ±2.29	15.35 ^{aA} ±2.05	15.10 ^{aA} ±1.39	72.45
100% MO	15.30 ^{aA} ±1.53	13.44 ^{aA} ±3.66	13.29 ^{aA} ±2.25	16.20 ^{aA} ±1.71	15.38 ^{aA} ±1.64	73.61

Where: MO: moringa oil; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same raw at ($P \leq 0.05$).

while minimum scores were given to the cake prepared from wheat flour supplemented with 20% moringa oil (66.50). The sensory characteristics (Color, Taste, Odor, Texture, Appearance and overall acceptability) values of cake supplemented with

20, 40, 60, 80, and 100% moringa oil during storage periods after 5, 10 and 15 days generally followed a similar trend as zero time. These results were in accordance with Shokery *et al.* [33] who illustrated that, prepared cup cake samples by replacing shortening with MO did not significantly affect the sensory characteristics. In some other studies normal shortening was also successfully replaced with oils to improve the quality of bakery products e.g., wheat germ oil, rice bran oil, sunflower oil and maize germ oil [40-42]. **The Staling rate of cake**

Alkaline water retention capacity (AWRC) measurements of cake treated with varying concentrations of moringa oil over storage times are shown in Table 8. Cake's alkaline water retention capacity (AWRC) may serve as a staling and freshness indicator. As a result, it was calculated for every sample both at zero time and following five, ten, and fifteen days of storage. The AWRC values of the control samples were the lowest; they decreased from 313.18% at zero time to 296.44, 281.48, and 276.35% after five, ten, and fifteen days of storage, respectively. The cake sample made by substituting 20, 40, 60, 80, and 100% moringa oil for shortening had higher AWRC values at the start of the storage period (335.41, 334.73, 322.76, 321.19, and 335.85%). At the conclusion of storage periods, however, the lowest values—296.66, 298.29, 297.84, 278.32, and 293.07% were recorded. The AWRC values of all supplemented samples at all levels decline throughout storage when cake is supplemented with varying amounts of moringa oil. As a general notice, as storage times rose, the AWRC values of various cake samples (control or varying quantities of moringa oil) decreased. However, across all storage times, the cake supplemented with 80% moringa oil showed the least increase in AWRC value. At zero time and following storage durations of five, ten, and fifteen days, its respective percentages were 321.19, 298.99, 285.61, and 278.32%. The samples supplemented with 100% moringa oil (335.85%) stored at zero time, 20% moringa oil (317.86%) stored after five days, 20% moringa oil supplemented after ten days (315.62%), and 40% moringa oil supplemented after fifteen days (298.29%) had the highest AWRC value. These lead to consensus. According to Shokery *et al.* [33], AWRC values significantly decreased as storage time increased. As MO was used in place of cake shortening, the staling rate was delayed and the cake's freshness was significantly improved as compared to the control sample. Additionally, as shown in Table 8, cake samples treated with moringa oil had a greater moisture content than the control sample during all storage periods, which might be the cause of these results. According to Sultan [42], cakes with higher moisture content often have a slower rate of staling.

Table 8: Staling of cake supplemented with different levels of moringa oil during storage periods.

Samples	zero time	After 5 days	After 10 days	After 15 days
Control	313.18 ^{cA} ±5.60	296.44 ^{bAB} ±7.39	281.48 ^{cB} ±4.17	276.35 ^{bB} ±0.75
20% MO	335.41 ^{abA} ±0.08	317.86 ^{aAB} ±0.06	315.62 ^{aAB} ±2.25	296.66 ^{ab} ±5.05
40% MO	334.73 ^{abA} ±4.33	310.44 ^{abAB} ±3.95	305.69 ^{abAB} ±2.00	298.29 ^{ab} ±0.68
60% MO	322.76 ^{bcA} ±2.53	301.69 ^{abA} ±7.25	300.34 ^{abA} ±0.56	297.84 ^{aA} ±5.18
80% MO	321.19 ^{cA} ±2.35	298.99 ^{bAB} ±0.86	285.61 ^{bcB} ±4.92	278.32 ^{bB} ±2.67
100% MO	335.85 ^{aA} ±0.23	301.62 ^{abB} ±2.21	293.22 ^{bcB} ±1.14	293.07 ^{ab} ±4.42

Where: MO: moringa oil; Results are presented as means for triplicate analyses ± standard deviation (SD). Means within column with different small letters are significantly different ($P \leq 0.0$) between samples, while a difference in capital letters indicates significant differences between different storage period of the same sample in the same row at ($P \leq 0.05$).

Texture profile analysis of cake

Table 9 shows the texture profile study of cakes with varying amounts of moringa oil. All cake samples added with varying amounts of moringa oil had higher hardness and gumminess ratings than the control sample. Samples with 20% and 80% moringa oil had the greatest hardness and gumminess values (13.95 and 13.47, respectively). Cake samples supplemented with moringa oil at all doses showed a decrease in springiness scores. When compared to the control, the reduction rate varied between 2.72 and 21.53%. The cohesiveness values of all supplemented cake samples decreased very slightly as the quantities of moringa oil were increased. 10% moringa oil supplementation level. The chewiness rating only rose to 47.74, the greatest value compared to the control. When cake was supplemented with moringa oil at levels 20, 40, 60, and 80%, the chewiness value decreased compared to the control. Samples containing 40% and 20% moringa oil had the lowest and greatest decrease values, respectively (7.43% and 18.85%).

Table 9: Texture profile analysis of cake with different levels of moringa oil

Samples	Hardness N	Springiness mm	Cohesiveness	Chewiness J	Gumminess N
Control	12.45	3.67	0.97	44.44	12.12
20% MO	13.95	3.13	0.95	41.24	13.20
40% MO	13.47	2.88	0.93	36.15	12.57
60% MO	13.35	3.13	0.92	38.29	12.25
80% MO	14.64	3.00	0.92	40.41	13.47
100% MO	13.88	3.57	0.96	47.74	13.37

Where: MO: moringa oil

Conclusion:

The chemical, physical, and nutritional properties of sponge cake are greatly impacted by the use of varying amounts of moringa seed oil. The use of moringa seed oil as a source of fats in fortifying certain bakery products as functional foods and improving their physical, chemical, technological, and sensory qualities is evident from all the data regarding the various compounds found in *Moringa oleifera* oil.

References

1. World Health Organization. World health statistics. World Health Organization. 2014
<https://iris.who.int/handle/10665/112738>.
2. Grundy, S. M. Obesity, Metabolic Syndrome, and Cardiovascular Disease. The Journal of Clinical Endocrinology & Metabolism. 2004; 89 (6): 2595-2600.
3. Felisberto M H F, Wahanik A L, Gomes-Ruffi C R, Clerici M T P S, Chang Y K, & Steel C J. Use of chia (*Salvia hispanica* L.) mucilage gel to reduce fat in pound cakes. LWT-Food Science and Technology. 2015; 63 (2): 1049-1055.
4. Zahn S, Pepke F & Rohm H. Effect of inulin as a fat replacer on texture and sensory properties of muffins. International Journal of Food Science & Technology. 2010; 45: 2531–2537.
5. Doweidar M M. Production and evaluation of gluten free cake. Bull. Fac. Agric. Cairo Univ., 2006; 57: 665-684.
6. Adegbe A A, Larayetan R A, & Omojuva T J. Proximate Analysis, Physicochemical Properties and Chemical Constituents Characterization of *Moringa Oleifera* (Moringaceae) Seed Oil Using GC-MS Analysis. American Journal of Chemistry. 2016; 6: 23-28.
7. Nguyen H N, Gaspillo PD, Maridable J B, Malaluan R M, Hinode H, Salim C, & Huynh H K P. Extraction of oil from *Moringa oleifera* kernels using supercritical carbon dioxide with ethanol for pretreatment: Optimization of the extraction process. Chemical Engineering and Processing. 2011; 50: 1207-1213.
8. Rahman, I. M. M., Barua, S., Nazimuddin, M., Begum, Z., Rahman, M.A., & Hasegawa, H. Physicochemical properties of *Moringa oleifera* Lam seed oil of the indigenous-cultivar of Bangladesh. Journal of Food Lipids. 2009; 16: 540-553.
9. Warra A A. Cosmetic Potential of Oil Extracts from Seeds and Nuts Commonly Found in Nigeria. Ahmadu Bello University Press Limited Ed., Zaria, 2014.
10. Meneghetti S M P, da Silva J P V, Serra TM & Gossmann M. *Moringa oleifera* oil: Studies of characterization and biodiesel production. Biomass and Bioenergy. 2010; 34: 1527-1530.
11. Chaiya B, Pongsawatmanit R. Quality of batter and sponge cake prepared from wheat-tapioca flour blends. Kasetsart J (Nat Sci). 2011; 45:305–313 ().
12. Abiodun O. A., Adegbite J. A., & Omolola A. O. Chemical and physicochemical properties of *Moringa* flours and oil. Global Journal of Science Frontier Research. 2012 12(1): 13–17.
13. Ijarotimi O. S., Adeoti O. A., & Ariyo O. Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated, and fermented *Moringa oleifera* seed flour. Food Science and Nutrition. 2013, 1(6): 452–463.
14. Abdulkarim S. M., Long K., Lai O. M., Muhammad S. K. S., & Ghazali H. M. Some physico-chemical properties of *Moringa oleifera* seed oil extracted using solvent and aqueous enzymatic methods. Food Chemistry. 2005, 93: 253–263.
15. Andrade G. F., Melo T. M. S., Guedes C. D., Novack, K. M., Santos, R. C., & Silva, M. E. Biological evaluation of crude and degummed oil from *Moringa oleifera* Seeds. Brazilian Archives of Biology and Technology 2011, 54, (5):1003–1006.
16. Arafat, M. G. Physico-chemical properties of oil produced from *Moringa oleifera*, *Jatropha curcas* and *Carthamus tinctorius* L seeds. International Journal of Advanced Research 2013, 1(4): 181–187.
17. Kurniaty, I., Febriyanti, Y. and Septian, R. Isolasi Protein Biji Kelor (*Moringa Oleifera*) Menggunakan Proses Hidrolisis. Prosiding Seminar Nasional Sains dan Teknologi Fakultas Teknik Universitas Muhammadiyah Jakarta (2018).
18. Khairy, L., Saadon, F., Varastegan, B., Yang, T. A., & Zzaman, W. Physical Chemical Properties of Fermented and Roasted Rambutan Seed Fat (RSF) as A Potential Source of Cocoa Butter Replacer. International Journal on Advanced Science, Engineering, Information Technology 2017, 7(1): 57- 63.
19. Zouboulis CC, Hossini AM, Hou X, Wang C, Weylandt KH, Pietzner A. Effects of *Moringa oleifera* Seed Oil on Cultured Human Sebocytes In Vitro and Comparison with Other Oil Types. Int J Mol Sci. 2023, Jun 19;24(12):10332.
20. Shamrad, H. Y., & Shakir, K. A. sesame oil extraction and antioxidant activity of lignans from locally cultivated sesame seeds (*Sesamum indicum* L.). The Iraqi Journal of Agricultural Science 2019, 50(1): 382-389.
21. Al-Taweel, S.K., Al-Anbari, I.H. and Al-Hamdani, H.M. Antioxidant identification, antimicrobial activity of *stevia rebaudiana* bertonii leaves extract on flavored milk. International Journal of Agricultural & Statistical Sciences 2022, 18(2).
22. Bennion EB and Bamford GST. The technology of cake making, 6th Ed. pp112-120, 277 and 285- 288. published by blacking academic and professional, Chapman & hall, London (1997).
23. Barakat Hassan and Ghazal Galal A. Physicochemical Properties of *Moringa oleifera* Seeds and Their Edible Oil Cultivated at Different Regions in Egypt. Food and Nutrition Sciences, 2016, 7: 472-484
24. AOAC. Official Methods of Analysis, 18th ed. Association of Official Analytical Chemists AOAC International, Gaithersburg, MD, USA, 2005.
25. Hunter RS. Scales for measurements of color differences. In Measurement of appearance, John Wiley ED., Interscience, 1975, New York, USA. 133 p.
26. AACC. Approved Method of the AACC. 10th ed., American Association of Cereal Chemists, INC. st., Paul, Minnesota, USA, 2000.

27. Yamazaki W T. An alkaline water retention capacity test for the evaluation of cookie baking potentialities of soft winter wheat flours. *Cereal Chemistry*. 1953; 30: 242-246.
28. Kitterman J S and Rubenthaler GL. Assessing the quality of early generation wheat selection with the micro AWRC test. *Cereal Science Today*. 1971; 16: 313-316.
29. Bodyfelt FW, Tobias J and Trout G M. *The Sensory Evaluation of Dairy Products*. AVI Publishing Co., 1988, New York, USA.
30. Duncan DB. Multiple range and multiple F Test. *Biometrics*. 1955; 11:1-42.
31. Eman OA. Preparation of low protein cake. *Egyptian J. Nutrition*. 1997; 12(2): 1-17.
32. Abd Elhadi MA and Nadir AS. Xanthane gum: Production and application. *Egyptian J. Nutrition*. 2001; 15(1): 1-25.
33. Shokery Amira M, Gibriel AY, Ali FA; Abdel-Razik M M and Hozayen AM. Effect of replacing shortening by moringa oil on quality and stability of cup cake. The 5th Conference on "Food Industry at the Service of Tourism" Alex. October 2012; 2: 384-412.
34. Abdelraouf, W., Mattar, A. A. A., El-Desouky, S. M., &Elrefaey, A. A. E. Preparation and characterization nanoemulsionmoringa oil by whey protein and application in ice cream as a food model. *Egyptian Journal of Dairy Science* 2023: 107-117.
35. Al-Sayed HMA and Abo-Elfetoh SM. Polysaccharides as an improvement agent in cake production. *Annals Agric., Sci., Ain Shams Univ., Cairo, Egypt*, 2003; 48(2):627-646.
36. Hamilton CR and Kristein D. Dose rancidity, as measured by peroxide value effect animal performance (2003). www.darlingii.com/pdf/pveffectanimalspro.pdf
37. Robards K, Kerr AF & Patsalides E. Rancidity and its measurements in edible oils and sank foods. *Analyst*. 1988; 13: 213-222.
38. Benade AJS. The potential of red palm oil-based shortening as a food fortification for vitamin A in the baking industries. *Food and Nutrition Bulletin*. 2001; 22(4):416-418.
39. Sharif, K.; Butt, M.S.; Anium, F.M.; Nasir, M.; Minhas, and Qayyum, M.N. Extension of cookies shelf life by rsing rice bran oil. *Int. J. Agri. Biol*. 2003, 5(4):455-457.
40. Jacob, J. and leelavathi, K. Effect of fat-type on cookie dough and cookie quality. *J. Food Eng*. 2007, 79:299-305.
41. Nasir, M.; Butt, M.S.; Anium, F.M.; Jamil, A. and Ahmad, I. Physical and sensory properties of maize germ oil fortified cakes. *Int. J. Agri. Biol*. 2009, 11(3):311-315.
42. Sultan,W.J. *Practical baking* 3th Ed. Pp.20-22, 49-51. The AVI Publishing company, INC., Westport (1982).