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Egyptian kishk as a fortificant: Impact on the quality of biscuit

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Abstract:
Introduction. Biscuit is a mass-consumption product worldwide. As biscuit contains low amount of protein, it can be fortified with protein-containing raw materials. In the present work, we fortified biscuit with kishk, an Egyptian dairy product, and evaluated changes in its physicochemical properties and volatile compounds.
Study objects and methods. We analyzed biscuit from wheat flour (control sample) and biscuit form wheat flour with 10, 20, 30, 40, and 50% of kishk (experimental samples). The experiments were carried out by using standard methods.
Results and discussion. The fortified biscuit samples showed higher lightness (L^*) values than control. The antioxidant activity in the biscuit increased with the increasing amount of kishk. Aldehydes were the main volatile compounds in all the biscuit samples, followed by sulfur-containing compounds and alcohols. The predominant aldehyde was benzldehyde. However, kishk in amounts more than 20% affected adversely the aroma, taste and texture, as well as volatile compounds of the biscuits. Both the control and fortified with kishk biscuits contained an increased amount of total phenolic compounds. Based on sensory evaluation and volatile analysis, the most acceptable amount of kishk for fortification of biscuit was 10%.
Conclusion. Fortification of biscuit with Egyptian kishk enhanced its protein, fat and fiber, as well as antioxidant activity at all levels of fortification with no significant effect on appearance and color. Further studies are needed to evaluate storage conditions and shelf life of biscuits with kishk.

Keywords: Kishk, biscuit, flour, hardness, antioxidant properties, volatile compounds, physicochemical properties

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INTRODUCTION

Today, nearly all levels of society consume biscuit as snacks or weaning for infants. It has pleasant aroma, various taste, low cost, and high stability during storage at ambient temperature [1]. Recently, the consumption of biscuit has increased, which encourages manufacturers to develop new formulations of biscuit with non-traditional raw materials to enrich the flavor of biscuit [2]. In addition, the increasing demand for functional and nutraceutical food products makes it possible to increase consumption of bakery products such as biscuit by fortifying it with protein, fiber and other essential constituents from various sources.

The fortification process provides several advantages, namely it can predict heart, coronary and diabetic diseases, as well as improve body functions. Generally, the main ingredients used in biscuit production include wheat flour, fat, sugar, eggs, emulsifiers, salt, etc. The chemical composition of these ingredients lacks for vitamins and protein (8–10%), which reduces the nutritional properties of bakery products [3–5]. Therefore, manufacturers have made efforts to replace the main ingredients of biscuit with more nutritional and healthy ones.

Egyptian kishk is characterized by high nutritive value and good stability during all year seasons. The chemical composition of Egyptian kishk includes a high content of essential fatty acids, especially oleic and linoleic, as well as a high concentration of essential amino acids, especially lysine, tyrosine, and proline [6]. The main ingredients of kishk are parboiled wheat and milk, which make kishk an available and rich source for vitamins, minerals and fiber [7, 8].

We found no research on improvement of the nutritional properties and volatile content of snacks like biscuit by replacing wheat flour with Egyptian kishk. Therefore, the current study aimed to reveal effects of various proportions of Egyptian kishk on the nutritional

Table 1 Formulation of biscuit fortified with Egyptian kishk

Ingredients	Control	Kishk 10%	Kishk 20%	Kishk 30%	Kishk 40%	Kishk 50%
Wheat flour, g	100.00	90.00	80.00	70.00	60.00	50.00
Kishk, g	–	10.00	20.00	30.00	40.00	50.00
Shortening, g	15.00	15.00	15.00	15.00	15.00	15.00
Baking powder, g	1.00	1.00	1.00	1.00	1.00	1.00
Salt, g	2.85	0.57	1.14	1.71	2.28	2.85
Milk, mL	20.00	20.00	20.00	20.00	20.00	20.00

Salt percentage in kishk = 5.7 ± 0.82%

composition, sensory characteristics, antioxidant activity, and volatile content of biscuit.

STUDY OBJECTS AND METHODS

The objectives of the study were biscuit without kishk (control samples) and biscuit with 10–50% of kishk (experimental samples). Kishk, wheat flour (72% extraction), sugar, shortening, and baking powder were purchased from the local market (Dokki, Egypt). Folin-Ciocalteu's reagent, ABST and DPPH were purchased from Sigma-Aldrich Canada (Ontario, Canada). All chemicals were of analytical grade.

The biscuit formulation was developed at the National Research Center (Dokki, Egypt) as described by Hussein *et al.* [9]. Control and experimental formulations are shown in Table 1.

Proximate composition. The biscuit samples and Egyptian kishk were analyzed for moisture, ash, crude fat, and crude protein contents using Association of Official Analytical Chemist' Approved Methods 925.10, 920.87, 920.85, 923.03, and 963.09, respectively [10]. The analyses were conducted in triplicate.

Rheological properties. Rheological properties of dough samples with different amounts of kashk were evaluated using a farinograph according to [11].

Physical characteristics of fortified biscuits. The volume and weight of three biscuit samples of each treatment were recorded. Specific volume was calculated by dividing of the volume to weight. The diameter, height and spread ratio (diameter/height) of the biscuits were determined according to the method described in [11]. The thickness and diameter of the biscuits were directly measured using STECO (Germany) as mentioned by Mc-Watters *et al.* [12]. The spread ratio was calculated as quotient of diameter and thickness. The biscuits were weighed (Precisa 105 A, Swiss) and the weight was expressed in grams. A total of ten biscuits were used for the measurement.

Color parameters. Surface color characteristics of biscuit (intact) were measured in terms of Hunter color parameters, namely L^*, a^*, and b^* values as mentioned by Dauda *et al.* For this, we used a spectrocolorimeter (Tristimulus Color Machine) with the CIE Lab color scale (Hunter, Lab Scan XE-Reston VA, USA) in the reflection mode [13]. The instrument was standardized with the white tile of Hunter Lab Color Standard (LX No. 16379): X = 72.26, Y = 81.94, and Z = 88.14 (L^* = 92.46; a^* = –0.86; b^* = –0.16). Color difference (ΔE) was calculated from a^*, b^* and L^* parameters using the Hunter-Scotfield's equation: $\Delta E = (\Delta a^2 + \Delta b^2 + \Delta L^2)^{0.5}$. A total of ten biscuits were involved in the experiment.

Texture analysis. The texture of the baked biscuit samples was determined by a texturometer (Brookfield, CT3-10 kg, USA) equipped with a cylinder probe (TA-AACC36). Texture profile analysis was conducted to determine hardness. The analyzer was set to perform two cycle measurements to give a two bite texture profile curve. Trigger load and test speed were 9.00 N and 2.5 mm/sec, respectively.

Sensory evaluation. The sensory properties were evaluated using the 9-point Hedonic scale where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely [14]. The analysis was carried out by 10 trained panelists for four sensory descriptors, namely appearance, color, odor, taste, and texture.

Total phenolic and antioxidant activity. Total phenolic content. The biscuit and Egyptian kishk samples were finely powdered and extracted with petroleum ether (40–60°C) to remove fats and resinous materials. The residues were thoroughly separately extracted with 500 mL of 70% methanol. The extract was filtrated through Whatman No. 1 filter papers and the filtrates were evaporated to dryness under reduced pressure on a rotary evaporator at 40°C.

Total phenols were evaluated using the Folin-Ciocalteu method described in [15]. The results were expressed as milligram gallic equivalents (GAE) per gram of biscuit.

Antioxidant activity. The methanol extract (25, 50, and 75 uL) was used for antioxidant activity determination. DPPH-radical scavenging activity and ABST assay were determined as described by [16, 17], respectively.

Volatile compound analysis. Extraction of volatile compounds. Volatile compounds of the biscuits under study were isolated by headspace solid phase microextraction (HS-SPME) sampling and analyzed by gas chromatography coupled with mass spectrometry (GC/MS) [18]. Ten grams of grinded biscuits were put into a 20-mL headspace vial fitted with a Teflon-lined septum. Volatiles were sampled for 30 min at 50°C from the headspace of the vial using DVB/CAR/PDMS fiber (Divinylbenzene/Carboxene/Polydimethylsiloxane, Supelco, Bellefonte, Pa., U.S.A.). The fiber was then immediately inserted into the injection port of the gas chromatograph for 5 min at 260°C.

Chromatographic conditions. A Hewlett-Packard HP5890II gas chromatograph coupled to a 5971 MSD quadrupole mass spectrometer was used. Chromatograph was equipped with a MDN-5 (60 m×0.25 mm×0.25 μm, Supelco) column. Operating conditions for GC/MS were the following: helium flow 0.6 mL/min, initial oven temperature 40°C (3 min), then 8°C/min to 200°C, and 20°C/min to 280°C (3 min).

Identification of volatile compounds. Volatile compounds were identified by comparison of their retention indices and mass spectra with standards, or, in some cases tentatively only by NBS 75K mass spectra library search and retention indices. Retention indices were calculated for each compound using homologous series of C_6–C_{22} *n*-alkanes [19].

Statistical analysis. Statistical analysis was conducted using SPSS software version 16 (SPSS Inc., Chicago, USA). All analyses were performed in triplicate and data reported as means ± standard deviation (SD). Data were subjected to analysis of variance (ANOVA). The confidence limits used in this study were based on 95% ($P < 0.05$) [20].

RESULTS AND DISCUSSION

Chemical composition of biscuit. Table 2 demonstrates the proximate chemical composition of biscuits without Egyptian kishk (control sample) and biscuits with 10–50% of Egyptian kishk (experimental samples). An increased amount of kishk from 10 to 50% resulted in an increased content of protein, fat, ash as well as fiber. The 50% kishk biscuit had the highest content of protein (9.38%) compared to the control sample (8.29%). A similar trend was found by Eneche, who revealed that biscuit fortified with pigeon pea flour showed an increase in protein content [21].

Values are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

In general, the increase in fat, fiber and ash of kishk supplemented biscuit can be explained by the high content of those ingredients in kishk. Similar findings were also obtained by Nazni *et al.* and Pastuszka *et al.* [22, 23]. On the other hand, total carbohydrates decreased with an increase in the amount of Egyptian kishk (Table 2).

In the current investigation, we also determined the total phenolic content of methanolic extract in kishk, as well as in the control and experimental biscuits. The obtained data were expressed as mg GAE/g. The results showed that the biscuits with kishk had increased total phenolic content (9.56–12.04 mg GAE/g) compared to kishk and the control biscuit (1.57 and 8.23 mg GAE/g, respectively). The highest phenolic content was revealed in the 50% kishk biscuits (12.04 mg GAE/g).

Rheological properties. Table 3 shows the rheological properties of wheat flour (control) and its mixtures with Egyptian kishk in different amounts (10, 20, 30, 40, and 50%). The water absorption, arrival time, dough development time (DDT) and weakening of dough increased with an amount of kishk. That may be due to high fiber and protein amounts containing in kishk, while fibers in wheat flour tend to bind more water**.** On the other hand, interaction of kishk fibers with wheat flour constituents and the added water may cause a decreased stability of dough.

In this context, Kim *et al*. reported that an increased proportion of rice grain dietary fibers in the recipe of bread increased the water absorption of dough [24]. Other researchers reported that an increasing amount of barley flour caused a progressive increase in water absorption, arrival time, and dough stability, with addition of gelatinized corn flour to wheat flour [24–26]. Whereas in our work, dough stability decreased with increasing Egyptian kishk content (Table 3).

Physical characteristics of biscuit. The studied physical characteristics (weight, volume, specific volume, diameter, thickness, and spread ratio) exhibited a significant effect ($P < 0.05$) of Egyptian kishk on the quality of biscuits (Table 4).

The weight and volume of the experimental biscuits were significantly lower than those of the control sample ($P < 0.05$). This effect may be due to higher

Table 2 Nutritional composition of Egyptian kishk and biscuit fortified with kishk

Samples	Moisture, %	Protein, %	Fat, %	Ash, %	Fiber, %	Carbohydrates, %	Total phenols, mg GAE/100 g
Kishk	8.41 ± 0.01	12.10 ± 0.24	3.92 ± 0.02	8.39 ± 0.20	2.59 ± 0.09	72.13 ± 0.51[a]	1.57 ± 0.12
Control	4.31 ± 0.06[a]	8.29 ± 0.04[a]	17.25 ± 0.01	2.58 ± 0.07	0.53 ± 0.01	71.35 ± 0.07[a]	8.23 ± 0.18
Kishk 10%	4.16 ± 0.06[b]	8.56 ± 0.05[a]	17.63 ± 0.06[a]	3.05 ± 0.08[a]	1.19 ± 0.03	69.56 ± 0.08	9.56 ± 0.32
Kishk 20%	4.19 ± 0.11[b]	8.79 ± 0.09[b]	17.90 ± 0.11[a]	3.64 ± 0.05[a]	1.84 ± 0.05[a]	67.83 ± 0.09[b]	10.35 ± 0.26[a]
Kishk 30%	4.49 ± 0.31	8.92 ± 0.03[b]	18.19 ± 0.17	4.31 ± 0.06[b]	1.93 ± 0.02[a]	66.65 ± 0.12[b]	10.82 ± 0.15[a]
Kishk 40%	4.58 ± 0.37	9.15 ± 0.07	18.42 ± 0.17[b]	4.89 ± 0.10[b]	2.08 ± 0.13	65.46 ± 0.18[c]	11.75 ± 0.16[b]
Kishk 50%	4.36 ± 0.22[a]	9.38 ± 0.16	18.53 ± 0.09[b]	5.31 ± 0.26	2.19 ± 0.02	64.59 ± 0.15[c]	12.04 ± 0.25[b]

Table 3 Rheological properties of dough with and without kishk

Samples	Water absorption, %	Arrival time, min	Dough stability, min	DDT, min	Dough weakening (B.U)
Control	58.00	1.50	7.50	3.00	70
Kishk 10%	59.50	1.50	4.50	2.00	100
Kishk 20%	61.00	1.50	2.50	3.50	115
Kishk 30%	62.00	1.50	3.50	2.00	120
Kishk 40%	63.50	2.00	2.00	3.50	170
Kishk 50%	65.00	2.00	1.50	2.50	185

Table 4 Physical characteristics of biscuit fortified with Egyptian kishk

Sample	Weight, g	Volume, cm^3	Specific volume, $cm^3 \times 100\ g^{-1}$	Diameter, cm	Thickness, cm	Spread ratio (W/T)
Control	7.23 ± 0.41^a	3.50 ± 0.08^a	0.48 ± 0.05^b	4.50 ± 0.12^a	0.33 ± 0.02^a	13.63 ± 0.19^a
Kishk 10%	7.26 ± 0.29^a	3.50 ± 0.11^a	0.48 ± 0.03^b	4.50 ± 0.09^a	0.33 ± 0.06a	13.63 ± 0.14^a
Kishk 20%	6.32 ± 0.31^c	3.50 ± 0.13^a	0.55 ± 0.09^a	4.53 ± 0.14^a	0.30 ± 0.07^b	15.11 ± 0.13^a
Kishk 30%	6.84 ± 0.15^b	3.36 ± 0.07^a	0.49 ± 0.02^a	4.50 ± 0.06^a	0.33 ± 0.05^a	13.63 ± 0.15^a
Kishk 40%	6.10 ± 0.17^c	3.33 ± 0.05^b	0.55 ± 0.06^a	4.07 ± 0.19^b	0.30 ± 0.09^b	13.53 ± 0.17^a
Kishk 50%	6.98 ± 0.62^b	3.37 ± 0.14^b	0.48 ± 0.07^b	4.03 ± 0.07^b	0.30 ± 0.04^b	13.43 ± 0.16^a

Values are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

Table 5 Effect of Egyptian kishk on hardness and color determinants of biscuits

Sample	Surface				Back				Hardness, g force
	*L**	*a**	*b**	Δ*E*	*L**	*a**	*b**	Δ*E*	
Control	60.16 ± 0.58^a	8.48 ± 0.62^a	32.44 ± 0.57^a	–	56.72 ± 0.99	11.25 ± 1.09^a	33.77 ± 0.65^a	–	39.28 ± 1.32^a
Kishk 10%	64.39 ± 0.76^b	8.71 ± 0.46^a	31.85 ± 0.59^a	4.29 ± 0.17	65.75 ± 3.05	9.27 ± 1.84^b	34.67 ± 1.32^b	9.36 ± 2.14	27.43 ± 5.22
Kishk 20%	63.53 ± 0.27	9.42 ± 0.92^b	30.93 ± 0.68^b	3.82 ± 0.35^a	60.29 ± 2.68^a	11.48 ± 1.41^a	33.70 ± 1.10^a	3.02 ± 0.50^a	34.24 ± 5.70^b
Kishk 30%	60.80 ± 0.95^a	9.05 ± 0.40^b	30.78 ± 0.45^b	2.05 ± 0.20^b	61.17 ± 1.56^a	10.24 ± 0.57	33.13 ± 0.87^b	4.74 ± 0.43^a	34.81 ± 7.38^b
Kishk 40%	61.51 ± 0.23^c	7.73 ± 0.23^c	29.92 ± 0.27^c	2.99 ± 0.38^b	62.55 ± 0.58^b	8.05 ± 1.24^b	31.01 ± 1.42^c	6.14 ± 2.93^b	40.32 ± 3.75^a
Kishk 50%	61.65 ± 0.34^c	7.79 ± 0.09^c	29.60 ± 0.39^c	3.32 ± 1.09^a	61.41 ± 0.47^b	7.96 ± 0.29	30.54 ± 0.06^c	6.58 ± 1.24^b	47.76 ± 6.82

Values are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

fiber and protein contents in kishk. Moreover, kishk also affected the diameter, thickness, and spread ratio of the biscuit. The results obtained by Brito *et al.* [27] showed a decrease of volume in cookies with higher amount of quinoa flour compared to that in cookies from corn starch.

In our work, due to the decrease in diameter in biscuit with Egyptian kishk, its surface also decreased compared to control. As we can see from Table 4, high amounts of Egyptian kishk showed a remarkable correlation with the decrease in physical properties of the biscuits. In other study carried out by Mofasser *et al.*, the authors found an increase in diameter of gluten-free biscuit compared to traditional biscuit [28].

Color values and hardness evaluation. The main criteria for the consumer to purchase the food product are its appearance and color. Table 5 demonstrates the color characteristics of the biscuits under study, namely *L**, *a**, *b**, and ΔE.

The lightness values (*L**) in the biscuits fortified with kishk were higher (60.80–64.39) than that in the control sample (60.16). Yellowness values (*b**) were found to be lower in the samples with Egyptian kishk (29.60–31.85) than in the control biscuit (32.44). A similar trend for color values in both surface and back of biscuit was observed. Redness (*a**) showed no significant difference between the control and fortified sample with 10% of kishk, as well as between 40 and 50% kishk samples in the surface analysis (Table 5). An opposite trend was found in back analysis, which had significant variation between the samples.

The main color characteristics of biscuit depends on the degree of caramelization, or Maillard reaction, and are affected by various factors such as protein, carbohydrates, water activity, pH, etc. Therefore, the processing conditions during baking should be controlled [29, 30].

We also analyzed the effect of kishk in biscuit on its textural properties, namely hardness (Table 5). The obtained results indicated that the increasing amount of kishk increased the hardness of biscuit from 27.43 to 47.76 g (for the 10 and for 50% kishk samples, respectively). The same trend was observed by Drisya *et al.* who added dehydrated *Murraya koenigii* powder to cookies [31]. Our results are also consistent with Parul *et al.*, who found that spirulina and sorghum flours incorporated in dough increased the hardness of biscuit [32].

Table 6 Sensory scores of biscuits fortified with Egyptian kishk

Samples	Appearance	Color	Aroma	Taste	Texture
Control	7.85 ± 0.67	8.00 ± 1.39	8.15 ± 1.23	8.30 ± 0.97	8.05 ± 1.02
Kishk 10%	8.85 ± 0.41	8.75 ± 0.62	8.80 ± 0.61[a]	8.70 ± 0.48[a]	8.70 ± 0.48[a]
Kishk 20%	8.50 ± 0.76[a]	8.35 ± 0.54[a]	8.25 ± 0.49[a]	8.30 ± 0.39[a]	8.15 ± 0.53[a]
Kishk 30%	8.30 ± 0.47[a]	8.10 ± 0.67[b]	8.05 ± 0.35	8.10 ± 0.48[b]	8.15 ± 0.53[a]
Kishk 40%	8.00 ± 0.75[b]	8.30 ± 0.58[a]	7.80 ± 0.59[b]	8.05 ± 0.52[b]	7.90 ± 0.70[b]
Kishk 50%	8.00 ± 0.79[b]	8.20 ± 0.59[b]	7.65 ± 0.75[b]	7.80 ± 0.73	7.75 ± 0.81[b]

Values are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$)

The highest hardness of the 50% kishk biscuit compared to the other samples may be explained by its high protein content [33]. A gradual increase in hardness of biscuits with increasing the Egyptian kishk amount may be due to water absorption by kishk. Therefore, it is important to control baking conditions during addition of kishk with the view to replace wheat flour. Nandeesh *et al.* also reported that 30% of differently treated wheat brans increased the hardness of biscuit dough and decreased its cohesiveness, springiness, and adhesiveness [34].

Sensory evaluation. Table 6 demonstrates the effect of replacing wheat flour with Egyptian kishk in biscuit on its sensory properties. We evaluated appearance, color, aroma, taste, and texture. All the attributes showed a lower score in the fortified samples compared to control. Our results are similar to those reported by Drisya *et al.* who used *Murraya koenigii* leaf powder in the amount of 10% to fortify cookies, and this amount was acceptable [31]. Bajerska *et al.*, who used green tea extract in bread, mentioned its adverse effect on the sensory properties of the bread [35]. These data may contrast due to significant differences in processing conditions for biscuit and bread.

The obtained results are in agreement with those reported by Patel and Rao, who fortified biscuit with black gram flour [4]. Another study carried out by Ezeagu *et al.*, who substituted wheat flour with 15% of *Muccuna* seed flour in biscuit, supported our findings [36]. The results of sensory evaluation were in parallel with the color metric measurements.

Antioxidant activity. Figure 1 shows antioxidant activity in the control and fortified biscuits determined by DPPH and ABST assays. Both assays revealed a pronounced increase in antioxidant activity with the increase of kishk amount in the dough. However, the DPPH assay showed better results compared to ABST. Our results are in good agreement with Galla *et al.*, who supplemented biscuit with spinach leaves extract in the amount of 5–15% [37].

The correlation coefficient (R^2) between total phenolic and antioxidant activity by DPPH and ABST methods were 0.973 and 0.984, respectively, which revealed that phenolic compounds are responsible for antioxidant activity in the biscuit samples. Phenolic compounds form in bakery products as a result of Maillard reaction and caramelization [38, 39].

With increasing amounts of kishk in biscuit, its antioxidant activity rose (Fig. 1). Biscuit fortified with marine collagen peptide, as reported by Kumar *et al.*, demonstrated a weak antioxidant activity due to low content of phenolic compounds, which is responsible for antioxidant activity [40]. Therefore, the improvement in the antioxidant activity of the biscuit fortified with Egyptian kishk in the present study may be due to formation of Maillard reaction products during bakery processing as reported by Krystyjan *et al.* and

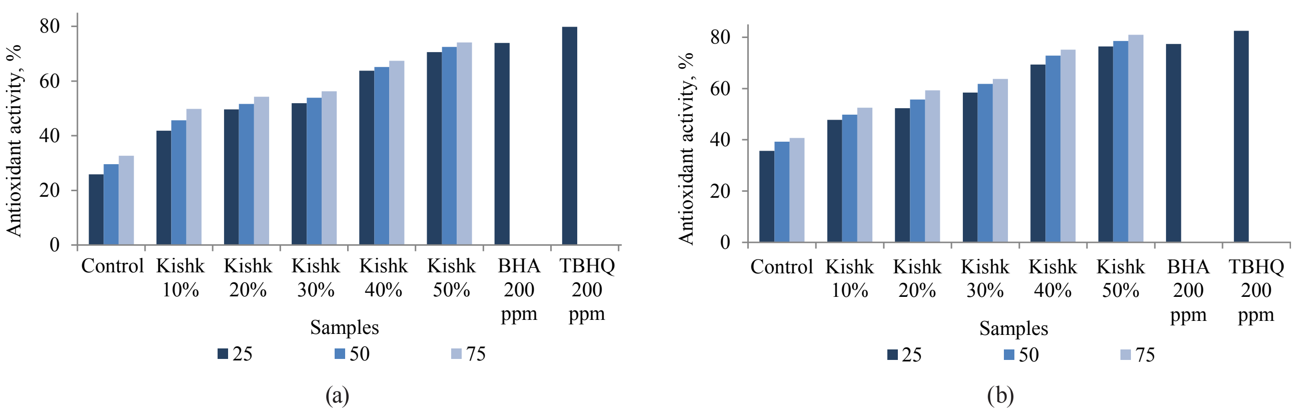

Figure 1 Antioxidant activity of biscuit fortified with Egyptian kishk determined by using DPPH (a) and ABST (b) assays. The same letters are not significant ($P \leq 0.05$)

Antoniewska *et al*. [41, 42]. The authors mentioned that antioxidant activity in biscuit and muffins was due to Maillard reaction products rather than polyphenols compounds. Therefore, a more detailed investigation on isolation and identification of Maillard reaction products formed in the fortified biscuit is needed.

Volatile compounds. Table 7 shows volatile constituents detected in the headspace of the biscuit samples fortified with Egyptian kishk. A total of 28 volatile compounds were identified and quantified. They were alcohols (4), aldehydes (9), ketones (2), carboxylic acids (2), esters (2) terpenes (1), and sulfur-containing compounds (8).

Aldehydes were the main group of volatile compounds in the biscuit samples, especially in the control biscuits, followed by sulfur-containing compounds and alcohols. The predominant aldehyde was benzldehyde (16.52%). The volatile compounds differed significantly among the control and fortified biscuits. The kishk-fortified biscuits showed higher levels of aldehydes, especially hexanal, heptanal and nonanal, which exhibited about a 2–10-fold increase compared to the control sample due to their presence in the raw material.

Iranmanesh *et al.* analyzed volatile compounds in dried kishk obtained from different animals. The authors

Table 7 Volatile compounds of biscuit fortified with Egyptian kishk

Volatile compounds	RI	Control	Kishk 10%	Kishk 20%	Kishk 30%	Kishk 40%	Kishk 50%	Organoleptics [48, 52]
				Alcohols				
1-Hexanol	863	1.93[b]	0.82	0.56	0.39	0.25	0.08	Resin, flower, green
Oct-1-en-ol	991	2.01	1.95	1.27	1.06	0.59	0.37	Mushroom, herbal earthy
1-Butanol	1182	1.46	0.19	0.83	0.57	0.18	n.d	Medicine, fruit
2-Furanmethanol	1665	7.12	5.23	4.19	0.45	2.93	1.58	
				Aldehydes				
2-Methylbutanal	647	2.75	2.04	1.62	1.29	0.78	0.38	Cocao, almond
3-Methylbutanal	668	4.18	3.51	2.78	2.55	1.78	1.49	Malt
Hexanal	805	6.37	7.12	8.53	10.16	11.35	11.96	Grass, tallow, fat
2-Furfural	841	6.83	4.53	3.91	2.87	1.09	0.87	
Propanal	847	0.15	3.92	0.86	0.59	0.37	0.34	Solvent, pungent
Heptanal	906	1.29	4.59	6.52	7.83	8.26	10.43	Fat, citrus, rancid
Octanal	1013	0.42	5.03	7.19	8.24	9.18	11.25	Fat, soap, lemon, green
Nonanal	1105	5.18	6.14	8.53	10.17	10.04	13.12	Fat, citrus, green
Benzldehyde	1521	16.52	12.93	10.92	9.84	9.76	8.23	
				Ketones				
2,3-Butanedione	695	1.95	1.57	0.98	0.73	0.54	n.d	
2,3-Pentanedione	702	0.72	0.93	0.62	0.85	0.39	n.d	
				Carboxylic acids				
Hexanoicsalysilate	1825	2.38	3.51	5.09	6.87	7.12	8.93	
Dodecanoicpalmitate	2516	0.95	n.d	3.62	5.64	5.29	6.78	
				Esters				
Ethyl acetate	1194	0.25	n.d	0.42	0.53	0.57	0.69	Pineapple
Ethyl hexanoate	1923	1.83	1.93	1.27	2.06	2.48	2.83	
				Terpenic compounds				
D-Limonene	1191	7.02	13.78	13.94	14.07	14.61	15.19	Lemon, orange
				Sulphur-containing compounds				
Pyrazine	721	2.19	1.52	0.93	0.75	0.62	0.49	
2-Methyl pyrazine	829	4.26	2.76	1.48	1.29	0.53	0.18	
2,6-Dimethyl pyrazine	927	0.98	n.d	0.65	0.42	0.18	0.07	
2-Ethyl-5-methyl pyrazine	998	1.35	1.72	1.28	1.09	0.95	2.13	
2-Penyl furan	1234	5.37	1.52	0.73	0.44	0.17	n.d	
2-Ethyl pyrazine	1332	6.59	5.98	4.18	n.d	3.54	0.16	
Acetyl pyrazine	1621	2.07	1.32	1.59	2.14	1.07	1.64	
2-Acetyl pyrrol	1972	4.52	2.06	2.86	3.76	1.49	0.58	

RI – retention indices

[b] Values are expressed as relative area percentage

n.d – not detected

detected aldehydes in all samples, with significant amounts in those samples containing flour during preparation [43]. Another explanation for the high levels of aldehydes in the fortified samples is thermal treatment of food products [44]. Among Strecker aldehydes forming via Maillard reaction, 2-Methylbutanal and 3-Methylbutanal were present both in the control and the fortified biscuit samples. However, significant amounts of hexanal, octanal, and heptanal were determined in the fortified samples compared to the control biscuit. This fact clarifies why the sensory properties the biscuits with high amounts of kishk had low scores. All the biscuit samples included alcohol. These compounds were identified in biscuit with purple wheat by Pasqualone *et al*. [45].

The furan compounds were mostly represented by furfural, a caramel-like odorant deriving by Maillard reaction, significantly more abundant in the control and 5% kishk samples, compared to the other fortified samples. Furfural is typically present in biscuits, which was reported in several studies [45, 47, 48]. Little amounts of pyrazines, produced by Maillard reaction, were also detected in the current research.

Mohsen *et al*. found three Strecker aldehydes in wheat cookies: 2-methylbutanal, 3-methylbutanal, and benzaldehyde. Those could have been derived from some amino acids, e.g. leucine, isoleucine or phenylalanine [45, 47]. These aldehydes are in good correlation with biscuit flavor which formed during preparation from Maillard reaction especially Strecker degradation [49–51]. In our study, we found that the biscuit fortified with kishk contained low amounts of these aldehydes (Table 7), which explains its low score of sensory evaluation. On the other hand, pentanal, 2-hexenal and alcohols, such as 1-pentanol, have an adverse effect on biscuit flavor due to linoleic acid oxidation [47, 52]. Low amounts of these aldehydes and alcohol make off-flavor with the increasing of kishk in biscuit (Table 7).

CONCLUSION

The current study found that fortification of biscuit with Egyptian kishk (10–50%) improved its nutritional composition such as protein, fiber, etc. The water absorption, arrival time, dough development time, and weakening of dough increased in the kishk-fortified biscuit. The fortified biscuit, especially the sample with 50% of kishk, also had higher lightness values (*L**) compared to the control sample. In addition, both the control and fortified with kishk biscuit contained an increased amount of total phenolic compounds. The antioxidant activity increased with increasing kishk amounts.

However, kishk had a negative effect on the sensory characteristics, physical properties, as well as volatile compounds of the biscuit. The kishk-fortified biscuits showed higher amounts of aldehydes, especially hexanal, heptanal, and nonanal. Further studies are needed to reveal effects of storage conditions on the physicochemical attributes and volatile compounds of kishk biscuits and to isolate and identify Maillard reaction products formed in the biscuits.

CONTRIBUTION

All the authors equally contributed to the study and are equal responsible for plagiarism.

CONFLICT OF INTEREST

The authors declare no conflict of interests related to the publication of this article.

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