Egypt. J. Chem. **Vol. 65**, No. 5 pp. 1 - 11 (2022)

Egyptian Journal of Chemistry

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

Impact of Jameed fortification on physicochemical, antioxidant and volatile compounds of snacks

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Abstract

Snacks fortified with Jameed are new candidates for use as protein supplements. The effect of the fortification of snacks with natural sources of protein such as Jameed at levels of 5%,10%, 15% and 20%, respectively on the physicochemical properties, antioxidant activity, nutritional, sensory properties and volatile compounds were determined compared to control snacks. The high levels of fortification characterized with high protein, fat, fiber and ash content. However, sensory data showed that snacks fortified with 5% Jameed recorded the highest score in sensory attributes. The results showed that the highest total phenolic content (1.29 mg/g) was found at 20% level compared to all treatments and control. The data exhibited a significant increase ($P \leq 0.05$) in antioxidant activity with the increase fortification level of snacks with Jameed. Thirty-three volatile compounds were identified in control as well as fortified snacks with Jameed at levels of 5 and 10% using GC-MS. The volatile compounds had arranged as following; 9 (alcohols); 8 (aldehyes); 5 (ketones); 3 (esters); 3 (furans); 3 (acids) and 2 (terpenes). The data indicated that the fortification with 5% Jameed recorded the highest sensory attributes may be related to the elevation of concentrations of aldehydes especially 2-methyl propanal, 2- methyl butanal and 3- methyl butanal as characteristic volatile in snacks.

Keywords: Fermented milk, Bakery products, Chemical composition, Antioxidant, Volatile

Introduction

Snacks are the most widely consumed bakery products around the world and becoming a major component of the international food market, which characterized by different flavor, crunchy texture and shape. The main ingredients in the formula recipe of snacks can be improved by several valuable components, which increase the healthy and sensory properties of snacks. The enrichment of snacks using protein from plant source mentioned by **Peksa et al. [2]** and from animal source by **Lee et al. [2]** as well as butyric acid and cysteine **[3]**.

Jameed is fermented milk produced by drying with various methods and classified as shelf-stable cheese. Jameed is very stable during storage due to its low moisture and pH, high level of salt and lactic acid bacteria which reduced the growth of pathogenic microorganisms **[4]**.The shelf-life of Jameed reach to years at room temperature without losing of nutritive value and spoiling. The excellent nutrition value of Jameed due to its high protein content about 57.02% and fat 22.25% which depend on the type of milk used in the processing (sheep, camel or goat) and method of fermentation **[5]**. The high quality of Jameed occurred when moisture content in the range of 15% to reduce the microbial spoilage and minimize the unfavourable changes in chemical or physical properties during storage **[6-7].**

Recently, consumers are interesting with functional foods that had high sensory attributes **[8]**. The fermented dairy products had several functional properties such as body's regulatory system, antibacterial, antioxidant, anti-cholesterol and anti-hypertensive **[9-11].** Therefore, different studies had carried out on fortification of bakery with fermented dairy products like bread **[12-13];** cookies **[14];** biscuit **[15-16]** and cake **[17]**. The information about the application of fermented dairy milk such as Jameed on snacks is scare. Therefore, the current study aimed to produce snacks supplemented with jameed and report its effect on physicochemical and antioxidant activity of prepared snacks. Additionally, the relationship between sensory evaluation of fortified snacks and volatile compounds was studied.

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Receive Date: 06 September 2021, Revise Date: 11 October 2021, Accept Date: 19 October 2021
DOI: 10.21608/EJCHEM.2021.94512.4442

Materials and methods

Wheat grains Variety (Giza 168) were obtained from Field Crops Department, Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt. The Jameed (made from camel milk) was purchased from a local market during 2019-2020 in Riyadh City in the Kingdom of Saudi Arabia, milled and placed into polyethylene bags for storage at 4°C until use. Sugar, shortening, active dry yeast and salt were purchased from the local market, Cairo, Egypt.

Milling

Wheat grains were manually cleaned, tempered to 14% moisture content, then milled using Quadrumat Junior flour mill (Model MLV-202, Switzerland). The obtained flour represent whole flour mill (100% extraction), then sieved to obtain flours of 72% extraction.

Preparation of flour mixtures

Four blends of flour mixed with 5%, 10%, 15 and 20% of Jameed were prepared and compared to control. The snacks prepared without adding Jammed was considered as control. The samples were stored in airtight containers and kept in a refrigerator until used.

Preparation and evaluation of snacks

Different blends were mixed at the rate of 100g blended flour with 1.5 g active dry yeast, sodium chloride (1.5 g), sugar (10g) and butter (10g). The dough was left to ferment for 1 hr for 30ºC at 85% relative humidity. The dough was divided to pieces each weighted 20 g, the pieces were arranged on trays and left to ferment for a further 30 min at the same temperature and relative humidity. The pieces of fermented dough were left again for 15 min at the same temperature and relative humidity then were baked at 230 ºC for 10 min. Snacks were allowed to cool on racks for about 1 h before evaluation.

Chemical composition

Moisture, ash, crude protein, fat and crude fiber contents were determined in raw materials and products (Snacks) samples according to the methods outlined in **[18].** Carbohydrates were calculated by difference as mentioned as follows:

Carbohydrates = 100 – (% protein + % fat + % ash + % crude fiber).

Rheological properties

Rheological properties of doughs were evaluated using Farinograph according to **[19].**

Determination of physical properties of snacks

The weight (W) and volume (V) of the snacks were measured to calculate the specific volume (SV) according to **[19].**

Color measurement

Surface (top and bottom) color characteristics of snacks (intact) were measured in terms of Hunter color parameters viz., L*, a* and b* values as mention by **Roncoliniaet al. [20]** using a spectrocolourimeter (Tristimulus Colour Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with 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 Hunter-Scotfield's equation as follows:

$\Delta E = (\Delta a^2 + \Delta b^2 + \Delta L^2)^{0.5}$

The measurement was carried out on ten snacks.

Total phenolic content and antioxidant activity

Preparation of extracts

The extraction procedure of phenolic compounds was performed as described by **Arapitsas [21].** The dried snacks samples were grinding into a powder, and 1.5 g was accurately weighed and dissolved in a beaker with 30 mL of 95 mL/100 mL aqueous methanol. Then, ultrasound-assisted extraction was performed for 30 min at 40 ºC. After standing for 0.5 h, the supernatant was transferred to a 100-mL, round-bottom flask. The residue was added to 30 mL of 95 mL/100 mL methanol solution, and the same extraction method was applied once again. After standing for 0.5 h, both supernatants were mixed and dried at 50 ºC in a rotary evaporator to remove methanol. After concentration, the extract was transferred to a 10-mL volumetric flask and diluted to the mark with 95 mL/100 mL methanol.

Determination of total phenolic content (TPC)

The Folin-Ciocalteu colorimetric method was used to determine the TPC of snacks samples as previously described **[22].** Briefly extracts of snacks samples (1 mL) were transferred to 25-mL volumetric flasks, after which 6 mL of distilled water was added. Then, 1 mL of Folin-Ciocalteu phenol reagent (diluted 10-fold in deionized water) was added to each flask, followed by 3.0 mL of sodium carbonate (7.5g/100mL) solution. After a 2-h reaction in the dark, a spectrophotometer was used to measure the absorbance at 765 nm, and 50% ethanol was used as a blank. The phenolic content was expressed as gallic acid equivalent (GAE, mg/g of dry sample) was used to determine TPCs.

DPPH radical-scavenging assay

DPPH-radical scavenging ability was measured as previously described **[23]**. Briefly, 2.0

mL of 0.14 mmol/L DPPH was added to different dilutions of extract (2.0 mL in anhydrous ethanol) and shaken uniformly. After standing for 30 min, the absorbance of the mixture was measured at 517 nm. Radical-scavenging activities were expressed as the IC_{50} and ascorbic acid equivalent antioxidant capacity (AEAC). The IC_{50} was determined as the concentration of extract when the removal rate of S was 50%. S was calculated using the following Eq.

$$S = A_0 - A_i/A_0$$

where A_0 is the absorption value in the absence of a scavenger, and A_i is the absorption value measured with the sample extract. The AEAC was expressed as ascorbic acid equivalents in mg ascorbic acid/g with the following Eq.

AEAC (mg ascorbic acid/g) = IC_{50} (ascorbic acid)/IC_{50} sample) X 10^3

Determination of ABTS antioxidant activity

The $ABTS^+$ radical cation decolorization assay was performed as described by **Choi et al. [24]** to determine the ABTS antioxidant activity. A 7 mmol/L ABTS stock solution was prepared by dissolving ABTS in sodium acetate-acetic acid buffer (20 mmol/L, pH = 4.5). An $ABTS^+$ working solution reaching a stable oxidation state was prepared by mixing 7 mmol/L ABTS and 2.45 mmol/L potassium persulfate at a 1:1 ratio, followed by standing in the dark for 12-16 h. This solution was further diluted with sodium acetate-acetic acid buffer (20 mmol/L, pH = 4.5) in a 1: 22.5 ratio to reach an absorbance of 0.70 ±0.02 at 734 nm. Stepwise dilution of extracts was performed by mixing 2.0 mL of the extract with 2.0 mL of $ABTS^+$ working solution, followed by standing for 30 min in the dark. Finally, the absorbance was measured at 734 nm, with absolute alcohol used as a blank. Ascorbic acid equivalents in mg ascorbic acid/g were also used to express the antioxidant capacity of ABTS.

Sensory evaluation of snacks

Snacks samples were evaluated for appearance (10), color (10), odor (10), taste (10), texture (10), and overall acceptability (10) at food and nutrition division, NRC according to the method described by **Chow & Wan [25].** The evaluation was carried out based on the intensity of the preference of panellists where, 1 indicated “extremely dislike”, 5 indicated “neutrality”, and 9 indicated “extremely like”.

Volatile compound determination

The volatile contents of prepared snacks at replacing levels of 5 and 10% as well as control samples were estimated as stated by Agilent technologies (Palo Alto, CA) HS autosampler (7697 A) was used to monitor the static HS quantitation of volatiles. Samples (about 1.0 g) were equilibrated for 50 min at 40 °C prior to analysis. The settings of the HSS 7697 A were 5 s for pressurization, equilibration, and filling and 2 min for injection. The HS loop (3 mL) temperature was set at 90°C. High-purity helium, filtered through moisture and oxygen traps (Hewlett-Packard), was used for vial pressurization, and an HSS sampler carrier gas at a flow rate of 17.5 mL/min was measured at the splitter outlet.

GC–MS analysis

Analyses were performed on Agilent 7890 GC coupled to a 5977 MS detector. Manual tuning of the MS with perfluorotributylamine was used to adjust relative abundance for *m/z* 69, 219, and 502. The MS was run in the scan mode (*m/z* range from 33 to 400 with a threshold of 100 and a sampling rate of 3 scans/s). Ultrapure helium was passed through moisture and oxygen traps and was used as the carrier gas. The following GC operating conditions were used: a silica capillary column HP-5 (60 m × 0.25-mm × 0.25-μm film thickness); a flow rate of 1 mL/min at 40°C; a split ratio of 1:10; the injection port set at 250°C and the interface line to the MS at 230°C; and the electron energy and electron multiplier voltage at 70 eV and 1647 V. The oven temperature was held for 5 min at 35 °C, then increased by 5 °C/min to 50 °C and held in isothermal conditions for 5 min, then raised to 210 °C at 5.5 °C/min, and finally held constant at 210 °C for 5 min.

Volatile compounds identification

The linear retention index (RI) values for unknowns were determined based on retention time data obtained by analyzing a series of normal alkanes (C_6-C_{22}). Volatile components were positively identified by matching their RI values and mass spectra with those of standards, also run under identical chromatographic conditions in the laboratory **[26]**.

Statistical analysis

The statistical analysis was conducted by using SPSS software version 16.0 and results were analysed using Duncan’s test at a significance level of 0.05. All the experiments were conducted in triplicates and mentioned as a mean ± standard deviation as reported by **Mc-Clave & Benson [27].**

Results and discussion

Chemical composition of fortified snacks

The data in **table 1**showed the proximate chemical composition of Jameed, control and tested snacks with different level of Jameed. Jameed had higher content of protein (33.52%) which could cause a significant increase in protein content of fortified snacks compared to control sample.

Replacing the wheat flour with Jameed had a remarkable effect on nutritional composition which represent by significant increase ($P < 0.05$) in protein, fat, ash and fiber (**Table 1)**.

Table (1) Gross chemical composition of control Snacks, Snacks with different levels of Jameed (g/100 g on dry basis)
Values are (Mean±SD); the same letters in the same column are not significantly different.
T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed.

Samples	Protein	Fat	Ash	Fiber	Carbohydrate
Jameed	33.52±0.33	5.19±0.03	2.19±0.013	—	59.10±0.49
Control	11.78±0.20[a]	9.38±0.07[c]	2.48±0.02[a]	0.54±0.03[c]	75.82 ±0.28[a]
T1	11.84±0.06[a]	9.69±0.11[a]	2.53±0.04[a]	0.65±0.01[a]	76.87±0.20[a]
T2	12.12±0.04[b]	9.74±0.04[a]	2.87±0.06[b]	0.67±0.03[a]	74.60±0.08[b]
T3	13.46±0.12[c]	10.03±0.12[b]	3.29±0.04[c]	0.74±0.03[b]	72.48±0.25[c]
T4	14.37±0.14[d]	10.17±0.10[b]	3.67±0.05[d]	0.79±0.03[b]	71.00±0.23[d]

This increase in nutrition composition may be due to the ability of Jameed as a fermented dairy product to absorb water and retain it.

The obtained results are in accordance with **Rahmati & Tehrani [28]** who found a similar increase in nutrition composition of cake fortified with soymilk in replace of milk and mentioned an increase in protein and crude fat. In the present study there is no significant difference in fiber and fat between fortification levels of 15 and 20 % (T3 and T4). The content of carbohydrates showed a reversible trend with decreasing as the fortification level increase and reach the maximum decrease at T4 with 71.00% compared to 76.87% at T1 (**Table 1)**. Our data confirmed by **Erfanian & Rasti [29]** who reported a significant decrease in carbohydrate of cake when fortification with soymilk. The most significant increase in chemical composition was found in protein which had 14.37 % at T4 (20% Jameed) compared to control and T1 (5% Jameed) which had 11.78% and 11.84% respectively (**Table 1**). Our data confirmed by **Yadav et al. [30]** who found a significant increase in protein of snacks supplemented with whey protein concentrate with levels ranged from 2.5-7.5% and mentioned increase in protein content from 8.2% in the control to 13.3%.

Rheological properties

The wheat flour (WF) and prepared snacks blend flour were subjected to analysis using Farinograph and Extinsograph to determine the rheological properties and the obtained data are given in **Table 2**. The studied parameters including water absorption and dough stability exhibited a significant increase with the increasing level of Jameed in comparison with control sample.

Table (2) Rheological properties of control snacks, 5% , 10% .15% and 20% of Jameed Snacks

Samples	Water absorption (%)	Arrival time (min)	Dough stability (min)	DDT (min)	Dough weakening (B.U)
Control (WF)	58.00	1.50	7.50	3.00	70
T1	60.00	1.50	7.50	3.50	55
T2	62.00	1.50	9.50	3.50	38
T3	65.00	1.50	11.00	4.00	35
T4	67.00	1.50	11.00	4.00	20

T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed

The lowest water absorption value was found in level of 5% (T1) when Jameed was used; these results in agreement with literature **[31-32]**. The high protein content in Jameed may explain the increase in water absorption. On the other hand, theincrease in dough developing time (DDT) indicate the mixing of Jameed with wheat flour to give dough that is more consistent. The obtained data are in accordance with **Hadnadev et al. [33].**

Physical properties

The effect of added Jameed on physical properties including weight, volume and specific volume of snacks are given in **Table 3**. The results showed a non-significant increase in weight between control and all fortified samples and a significant decrease in volume and specific volume had occurred.

Table (3) Physical characteristic of snacks fortified with different levels of Jameed

Sample	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
Control	13.50[a]	25.67[b]	1.90[b]
T1	13.50[a]	25.67[b]	1.90[b]
T2	13.53[a]	31.00[a]	2.29[a]
T3	13.83[a]	25.67[b]	1.86[b]
T4	13.90[a]	24.00[b]	1.73[c]
LSD	**1.114**	**2.018**	**0.093**

T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed

These variations may be due to high content of Jameed from protein, which ranged from 47.75-61.53% as reported by **Aludatt et al. [34]**. Our results in contrast to **El-Shebiniet al. [35]** who mentioned that the addition of doum flour caused a significant increase in biscuit volume and specific volume. In study carried out by **Fiorda et al. [36]** who noticed a similar trend in higher volume and specific volume in snacks fortified with starch of cassava.

Color analysis of snacks fortified with Jameed

The main quality attributes which affect the consumer preference and food acceptance is the color**.** During purchasing, the consumers used the color and appearance of food products as indicator of freshness and flavor quality **[37-38]**.Therefore, the color measurements of fortified snacks with Jameed at different levels were conducted on surface as well as crumb and the obtained data are given in **Table 4**. The most light sample (low L- value) was found in fortified snacks at 5% (T1) and control sample which represent 47.50 and 48.61 respectively compared to the highest fortified snacks at 20% (T4) which had 51.49 (**Table 4**) in surface analysis.

Table (4) Effect of Jameed addition on colour measurements of control and snacks samples

Sample	Surface				Crumb			
	L*	a*	b*	ΔE	L*	a*	b*	ΔE
Control	48.61±0.10	14.97±0.13	34.22±0.09[a]	—	54.83±1.12	4.22±0.90	24.89±1.11	—
T1	47.50±0.59	13.77±0.25	30.93±0.37[b]	1.63±0.20[a]	53.58±0.55[b]	7.21±0.42	27.70±0.32	8.37±0.98[a]
T2	50.75±0.13[a]	11.43±0.88	31.17±1.19[b]	3.01±0.37[b]	55.29±0.59[a]	9.29±0.38[a]	29.35±0.44	8.78±1.21[a]
T3	50.56±0.29[a]	12.49±0.43[a]	32.34±0.29[c]	3.96±0.14[b]	55.89±0.56[a]	9.32±0.57[a]	30.81±0.46[a]	9.30±1.20[b]
T4	51.49±0.40	12.26±0.46[a]	33.12±1.07[a]	4.12±0.36[d]	56.61±0.71[c]	9.45±0.08[a]	30.81±0.18[a]	9.56±1.14[b]

Values are (Mean±SD); The same letters in the same column are not significantly different**.**
T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed

A similar observation was recorded in crumb but with higher values compared to surface analysis. The fortified snacks showed lowest a and b-values as well as ΔE compared to control sample especially at 5 and 10% levels (T1 and T2). The samples with 20% level of Jameed (T4) indicating more yellow and brightness with highest score of b-value, which represent yellowness-blueness, color measurement by colorimeter. The snacks fortified with 5% Jameed (T1) had the lowest a and b-values in both surface and crumb which indicate more brighter and intense saturated orange color compared to the other levels of fortification (**Table 4**). These results are in agreement with **Goranova et al. [39].**

Total phenolic and antioxidant activity

The effect of fortification of snacks with Jameed on total phenolic content was determined using Foiln-ciocalteu method and the obtained data are given in **Table 5.**The data showed that the smallest value of total phenolic and antioxidant activity were in control sample in comparison with all fortified snacks with Jameed. The results showed that the highest total phenolic content (1.29 mg/g) was found in T4 compared to the other levels of fortification and control treatment.

Table (5) Changes in total phenolic content and antioxidant activity of snacks fortified with different levels of Jameed

Sample	Control	T1	T2	T3	T4
TPC (mg GAE/g)	0.26±0.04	0.91±0.07[a]	0.97±0.03[a]	1.05±0.06[b]	1.29±0.08[c]
DPPH IC_{50} (mg/mL)	0.89±0.08[a]	0.72±0.06[b]	0.69±0.03[c]	0.46±0.02[d]	0.27±0.05[e]
AEAC (mg V.C/g)	6.23±0.12[a]	6.39±0.02[a]	7.18±0.14[b]	8.27±0.13[b]	9.18±0.02[d]
ABTS (mg V.C/g)	12.48±0.16	13.75±0.14[a]	13.85±0.16[a]	14.69±0.08[b]	14.92±0.05[b]

Values are (Mean±SD); the same letters in the same row are not significantly different**.**
T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed
TPC: Total phenolic content; ascorbic acid equivalent antioxidant capacity

The evaluation of antioxidant activity was determined by DPPH and ABST methods and the results are showed in **Table 5.**The evaluation of antioxidant activity in food products using DPPH free radicals is commonly used as recommended by **Lou et al. [40].** The results of DPPH method showed that T4 (20% Jameed) had the lowest value of IC_{50} (highest AEAC values) followed by lower levels of fortification with Jameed (**Table 5**). Our results in accordance with **Calligaris et**

al. [41] who mentioned that Maillrad reaction products (MRPs) improve the antioxidant activity significantly of milk when heated at 120 ºC. They explained the antioxidant activity due to melanoidins, which had strong antiradical activity via Maillrad reaction during thermal treatment. Therefore, the high antioxidant activity of fortified snacks with fermented Jameed herein may be related to Maillard reaction products during processing condition since baked at 230 ºC for 10 min. The raw materials used in preparation for snacks either wheat flour or Jameed contain the reducing sugars and amino acids. The utilization of high temperature for baking allows the generation of melanoidins which correlated with antioxidant activity and another biological activities **[42]**. Several reports mentioned the formation of melanoidins in baked and snacks and recorded its excellent antioxidant activity **[43-44]**.

Another explanation for the increase in antioxidant activity of fortified snacks may be due to the presence of protein peptide in fermented milk as mentioned by **Nishino et al. [45]**. The main source of active peptide formed in fermented milk and the activity of peptides as antioxidant depend on the type of milk and conditions of fermentation [46]. On the other hand, **Bressa et al. [47]** noticed no changes in antioxidant activity during storage of thermal treated milk reported a significant increase in antioxidant activity in heated milk.The determination of antioxidant by ABST method showed a similar trend as found by DPPH method with higher values (**Table 5**).

Sensory evaluation

Assessment of snacks fortified with Jameed by sensory evaluation depends mainly on personal acceptability and subjective evaluation towards snacks. The data are not absolute but represent the consumer preference. **Table 6** exhibited the mean scores of sensory evaluation of snacks after added several levels of Jameed ranged from 5 to 20%.

Table (6) Sensory evaluation of control Snacks , Snacks with different levels of Jameed

Samples	Appearance	Color	Odor	Taste	Texture	OAA
Control	8.98±0.52^{a}	8.80±0.61^{a}	8.70±0.48^{a}	8.90±0.42^{a}	8.85±0.51^{a}	8.85±0.34^{a}
T1	9.20±0.58^{b}	9.15±0.41^{b}	8.98±0.65^{b}	9.23±0.41^{a}	9.17±0.60^{b}	9.26±0.22^{b}
T2	9.12±0.62^{b}	9.13±0.42^{b}	8.95±0.48^{b}	9.17±0.48^{b}	9.10±0.42^{a}	9.11±0.17^{b}
T3	8.48±0.47^{c}	8.35±0.66^{c}	8.83±0.53^{b}	8.85±0.34^{a}	8.90±0.59^{a}	8.87±0.17^{a}
T4	8.32±0.58^{c}	8.28±0.82^{c}	8.45±0.78^{c}	8.40±0.66^{c}	8.52±0.76^{c}	8.40±0.27^{a}

OAA: Overall acceptability; Values are (Mean±SD); the same letters in the same column are not significant.
T1: 5% Jameed; T2:10%Jameed; T3: 15% Jameed, T4:20%Jameed

The results showed that there is no significant difference in appearance, color and overall acceptability between 15 and 20% levels of fortification compared to control and other levels of fortification. Generally, all fortification levels recorded values more than 8.28 which reflected the high acceptability and degree of likeness towards fortified snacks. The supplementation levels of 5 and 10% received the highest score for odor and overall acceptability. Therefore, these levels as well as control treatment were subjected to analysis using GC and GC-MS to determine the relationship between sensory evaluation and volatile compounds. The snacks fortified with 20% level (T4) showed the lowest score of all studied sensory attributes compared to control and all other level of fortification (**Table 6**).

The addition of Jameed with 5 and 10 % (T1 and T2) showed an increase in taste, texture and overall acceptability compare to 15 and 20% (T3 and T4) as well as control sample. An opposite trend was observed in odor, color and appearance scores (**Table 6**). The obtained results reflect a decrease score from 9.17 (T1) to 8.52 (T4) in texture properties due to hardness. These data are in agreement with **Nilufer-Erdil et al. [48]** who mentioned that bakery products recorded higher hardness with high concentration of soybean protein. In addition, **Lin et al. [49]** found an increase in hardness of cake fortified with soy protein isolate when replaced the egg in cake manufacture which explain the reduce in sensory scores.

The reduction in sensory attributes in the present study at high levels of Jameed in accordance with **Yadav et al. [30]** who reported a reduction in overall sensory scores of snacks fortified with whey protein concentrate at level more than 5% which recorded 7.5/9 by fifty untrained panelists.

Volatile compounds

Thirty-three volatile compounds were extracted and identified in control as well as fortified snacks with Jameed at levels of 5 and 10% using GC-MS as well as their odor description and the obtained data are given in **Table 7.** The available odor descriptors and the formation source of volatile compounds were obtained from the literature **[50-52]**. Several classes were identified and sources for volatile arising such as fermentation, Maillard reaction and lipid oxidation **[53-55].** The volatile compounds had identified and arranged as fowling; 9 (alcohols); 8 (aldehyes); 5 (ketones); 3 (esters); 3 (furans); 3 (acids) and 2 (terpenes) as shown in **Table 7**. The data indicated that the fortification with 5% Jameed recorded the highest sensory attributes which may be due the high concentrations of aldehydes especially 2-methyl propanal (sweet, flower, solvent), 2-methyl butanal (cheese, sweet, chocolate) and 3-methyl butanal as characteristic volatile in snacks. Our results in accordance with **Ktenioudakiet al. [56]** who studied the changes in sensory acceptance of snacks fortified with brewer's spent grain and volatile compounds. Among the identified aldehydes were octanal and nonanal which are products of linoleic and oleic acid oxidation **[57-58]**; which present in high concentrations at 5% fortified level which had 2.29% and 3.23% respectively compared to control and 10% Jameed level of fortification **Table 7**.The contribution of volatile compound to the food depends on the food matrix and odor threshold **[59]**. The high concentrations of some aldehydes especially 2-and 3-methyl butanal as well as pentanal when fortification of snacks with Jameed was found in the current study correlated with their formation during processing or stored of Jameed **[60-61]**. The fortification of snacks with Jameed altered the volatile compounds profile in which correlated with sensory evaluation **(Table 6**). The main effect of Jameed on ketoes is the increase value of 2,3-butanedione at 5% level of Jameed which record 14.26% followed by control sample and fortified level 10% Jameed which had 13.49% and 10.28% respectively (**Table 7**).

The analysis of volatile compounds in fortified snacks with Jameed encourage using it in manufacture of some bakery products when we try to reduce the level of salt and obtain acceptable flavor and taste. The high concentrations of alcohols such as ethanol and 1-pentanol in treated snacks with Jameed when represent 5.07% and 4.16% respectively (**Table 7**) at 10% level of fortification may be due to the presence of these alcohols in Jammed. **Varming et al. [62]** who studied the volatile compounds in three cheese powders made from three types of cheese and mentioned the significant high concentrations of alcohols in prepared powder that are similar to Jameed processing.

The fortified samples characterized with the presence of terpenes, ketones and some aldehydes in comparison with control sample. For instance both identified of terpenes (myrecene and □-terpinene) were in significant higher concentrations which had 6.42% and 5.19% respectively at 10% level of Jameed (**Table 7**) compared to control treatment 2.46% and 1.83% respectively. With the increase of level of fortification a noticeable increase in the aforementioned terpenes had occurred. A similar observation was observed in esters and 2-butanone as the main identified ketone in fortified snacks with Jameed.

Small concentrations of identified organic acids in fortified snacks such as decanoic acid and hexanoic acids which represent 2.43% and 1.75% at 10% level of Jameed are typical volatiles of lipolytic enzyme activity **[63]**. The hard cheese powder like Jameed contains intermediate concentrations of organic acids as mentioned by **Curioni & Bosset [64].**

Table (7) Volatile constituents of snacks fortified with different Levels of Jameed

Volatile compounds	KI[a]	Control	5%	10%	Source	Descriptors
Alcohols						
Ethanol	617	2.45	2.95	5.07	Fermentation	Alcoholic
1-Butanol	1153	3.16	2.14	1.45	Fermentation	Floral, fruity, sweet
1-Penten-3-ol	1169	2.15	2.37	3.02	Lipid Oxidation	
1-Pentanol	1268	3.12	4.86	4.16	Fermentation	
2-Ethyl-1-butanol	1317	1.29	1.38	2.31	Fermentation	
4-Methyl-1-pentanol	1329	0.92	1.05	0.28		
3-Methyl-3-buten-1-ol	1334	2.38	3.19	1.57	Fermentation	
3-Methyl-2-buten-1-ol	1339	2.19	3.46	3.19		
1-Hexanol	1387	0.48	1.38	2.14		
Aldehydes						
2-Methyl propanal	805	3.67	4.17	2.03	Fermentation	Sweet, flower, solvent
2-Methyl butanal	906	10.26	11.59	8.47	Fermentation	Cheese, sweet, chocolate
3-Methyl butanal	911	8.17	9.51	6.89	Fermentation	Malty, chocolate, cocoa
Pentanal	967	3.68	1.09	5.94	Fermentation	
Nonanal	1079	1.29	3.23	0.19	Fermentation	Fatty

Heptanal	1187	3.28	1.43	1.27	Fermentation	Rancid
Octanal	1298	2.06	2.29	n.d	Fermentation	Fatty
2-Heptenal	1335	1.59	0.37	1.89	Fermentation	
Esters						
Hexyl acetate	1276	3.42	4.26	4.95	Fermentation	
Ethyl heptanoate	1340	4.26	4.19	5.46	Fermentation	
Ethyl octanoate	1435	1.52	1.67	2.04	Fermentation	
Ketones						
2-Butanone	893	3.98	4.62	4.96	Maillard	Butterscotch
2,3-Butanedione	1059	13.49	14.26	10.28	Fermentation	Buttery, cheesy
2-Heptanone	1176	4.06	0.37	0.24	Maillard	Fruity, cinnamon, green
1-Hydroxy-2-propanone	1305	0.38	0.19	n.d	Maillard	
3-Hydroxy-2-butanone	1287	1.67	3.17	0.58	Maillard	
Furans						
2-Ethylfuran	936	3.48	0.82	0.59	Maillard	
2-Butylfuran	1137	2.86	3.15	3.14	Maillard	
2-Pentylfuran	1238	2.79	1.37	0.39	Maillard	
Acids						
Hexanoic acid	948	n.d	0.42	1.82	Fermentation	Sweaty, cheesy
Nonanoic acid	1265	n.d	0.51	1.26	Fermentation	Sweaty, acidic
Decanoic acid	1379	n.d	0.16	2.43	Fermentation	Fatty, rancid
Terpenes						
Myrcene	994	2.13	2.46	6.42		
□–Terpinene	1175	1.83	1.52	5.18		

[a:] KI: Kovat index; [b]: Values are expressed as relative area percentage; n.d: not detected

The high scores in taste of fortified snacks with Jameed especially at 5% in comparison with control snacks (**Table 6**) may be due to that hard cheese powders like Jameed had desirable odor and flavor as mentioned by **Yamaguchi et al. [65]** who recorded 'Goya' flavor and odor as well as umami taste and harmony which enhancing the taste properties. Also, the high concentration of 3-hydroxy-2-butanone in fortified snacks at 5% Jameed which had 3.17% compared to control and 10% level of Jameed (**Table 7**) may explain the high sensory scores. Our data confirmed by **Burdock [63]** who found a strong relationship between 3-hydroxy-2-butanone and sensory description as Goya flavor and odor. On other hand, the slight decrease in taste of 10% Jameed level correlated with the high concentration of organic acid, which had sour taste in cheese powder and stored cheese. Another reason for this reduction may be due to casein peptides as studied by **Ardo& Pettersson [66].**

Conclusion

Based on proximate analysis, it could be concluded that the snacks prepared with Jameed as dried fermented dairy products had high protein content, lower specific volume and very acceptable till level of fortification 10%. The lightest sample (low L- value) was found in fortified snacks at 5% (T1) and control sample compared to the highest fortified snacks at 20% (T4) in surface analysis. All studied fortification levels recorded overall acceptability values more than 8.28 which reflected the high acceptability and degree of likeness towards fortified snacks. The supplementation levels of 5 and 10% received the highest score for odor and overall acceptability. The analysis of volatile compounds in fortified snacks with Jameed encourage using it in manufacture of some bakery products when we try to reduce the level of salt and obtain acceptable flavor and taste.

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