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Physico-Chemical, Sensory and Nutritional Evaluation of Date Bars Fortified with Different Levels of Germinated Flaxseed Powder

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Abstract: The objective of the current investigation was to determine the impact of germinated flaxseed powder (GFP) addition into date paste on nutritional, and sensorial parameters of produced date bars. Date paste was partially replaced with 0, 4, 8, 12 and 16% of GFP. The obtained mixture was formulated to small date bars. Chemical composition, minerals, fatty acid profile, amino acids as well as sensory characteristics of supplemented date bars were evaluated. The highest fat content was found in date bar samples containing 16% GFS (1.61%), while the lowest fat content was observed for control sample without additions (0.45%). Increased GFSs powder in the blending proportion caused significant increases in protein content of fortified date bars. Date bars fortified with 12 and 16% GFSs powder had protein contents that were approximately 2.34 and 2.51 times higher than those in unfortified bars without the addition of GFSs powder, respectively. In comparison to the control bar samples without the addition of GFSs powder, the carbohydrate content of date bars significantly decreased ($p \leq 0.05$) when 12 and 16% GFSs powder was added. Micro- and microelement concentrations were found to be highest in date bars fortified with 12 and 16% GFSs powder while the lowest contents were observed for control date bars without GFSs addition. Date bars supplemented and enriched with various levels of GFSs powder showed considerable increases in the content of poly-unsaturated fatty acids. The levels of isoleucine, leucine, total sulfur amino acids, total aromatic amino acids, as well as total essential amino acids, have been increased by adding different amounts of GFSs powder into date paste. There were no statistically significant differences in overall acceptance among any of the date bar samples up to 8% GFSs powder supplementation.

Keywords: Flaxseed Powder, Date Bars, Fatty Acids, Protein, Micronutrients, Organoleptic Evaluation

1. Introduction

Date palm tree (*Phoenix dactylifera* L.) Date palm tree is a member of Arecaceae family (Angiosperms, monocotyledon). In North Africa and Southwest Asia, the date tree is regarded as one of the oldest crops. In addition, date trees can be grown in Australia, Mexico, South America, southern Africa, and the United States [1, 7, 17]. Date fruit (*Phoenix dactylifera Linnaeus*) is one of the most ancient medicinal and functional foods. In the Arab Gulf region, dates have traditionally been regarded as staple food (Erskine et al., 2004). Date fruits can be consumed at fresh 30%–40%) or dried (60%–70%) forms. Date fruit is an excellent source of carbohydrates, dietary fibers, proteins, vitamins, minerals as well as bioactive compounds [3]. Date fruits' primary chemical components are carbohydrates., 70% of the date fruit's weight is made up of carbohydrates, the majority of

which are reducing sugars like glucose and fructose, non-reducing sugars like sucrose, and trace amounts of polysaccharides [4]. Date fruits contain a high level of dietary fiber (6.5–11.5%), fat (0.2 – 1%), protein (2 – 5.6%), and ash (2 – 3%) [38, 4, 6].

Blending date fruits with other rich natural foods could improve and enhance the nutritive values of [3]. In order to meet the requirements of individuals of all ages for protein and energy, various fruits are processed to formulate fruit bars that are ready to eat. [1]. Different fruits, cereals, and legumes are incorporated in these bars. as a primary component [13]. Nutritional studies suggest incorporation of omega 3 fatty acid sources into diets. In this regard, Flaxseed (Linseed) is one of the oldest crops, having been grown since the beginning of civilization [24]. Flaxseed (*Linum Usitatissimmum*) belongs to the Linaceae family. 20 to 30% of flaxseed's weight is made up of crude protein, It is a rich source of alpha linolenic acid linolenic acid, a type of omega-3 fatty acid [15]. Flaxseed is also an excellent source of the lignan component [18]. To improve the nutritional qualities of legume seeds, several processing procedures such as frying, soaking, roasting, and sprouting are used [2]. The nutritional characteristics of pulses are significantly impacted by sprouting and cooking, which improves the bioavailability of nutrients and also increases digestion and absorption. with nutrients [12]. Consequence, date fruit bars are a fine alternative to fresh fruits, particularly during the off season, and may be marketed to any region where this fruit is not cultivated (Munir et al., 2018). In order to develop products with a balanced diet, Parimita and Arora [32] designed date bars enriched with whey proteins. In this regard, Parn et al., 2015 developed date bars free of artificial ingredients using two different date varieties Munir et al., [26] used date paste and oats to produce unique date-based confectionery bars for customers, particularly youngsters.

The aim of the current study was to determine the effect of incorporation different amounts of germinated flaxseed powder (GFP) into date paste on nutritional and sensorial properties of date bars.

2. Materials and Methods

20 Kg of Sukkari dates (*Phoenix dactylifera* L.) were purchased from the Central Dates Market in in Buraydah, Qassim, Saudi Arabia. Flax (*Linum usitatissimum* L.) seeds were obtained from the local market in Buraydah, Qassim, Saudi Arabia.

2.1. Preparation of Germinated Flax Seeds

Germination process was carried out using the technique described by Kaur et al. [23]. Flax seeds were manually prepped to remove foreign items and then disinfected with a 70% ethanol solution for 15 minutes at room temperature before being washed with running water. The washed seeds were immersed in pure water (1:5, w/v) at ambient temperature (25°C) for 2 hours. The water was evacuated, and the seeds were placed between multiple slabs of cotton material and left to germinate for 24 dried for 24 hours in electric oven (ED series 53; Binder GmbH; Tuttlinggen, Germany) at 50°C. The dried seeds were crushed in a Kenwood electric grain grinder, sieved through a 150-m sieve size, and kept in glass jars at 4°C for further analysis.

2.2. Date Fruit Bar's Formulation

The pulp of date fruits was separated from the pits. The date pulp fruits were ground into paste using a kitchen mill (Moulinex, HV8 Pro, 2200W)) for 3 min. The obtained date paste was then partially replaced with 0, 4, 8, 12 and 16% of germinated flax seeds powder. The obtained mixture was formulated to small bars of 2.0cm width, 0.5cm height, and 4 cm in length. The date bars were kept in a cold room at 20°C for 3hours before sensory evaluation The cold bars were packed individually with polyethylene foil and plastic packaging. The date bar samples were stored at -18°C for further testing.

2.3. Proximate Composition Analysis

Date bar samples were analyzed for chemical properties. Date bar samples were analyzed for moisture, crude ash, crude proteins, crude fiber and crude fat using AOAC methods AOAC [9].

Moisture was measured using the AOAC [9] standard method 925.09. A clean, dry, and covered flat metal dish was weighed, and about 10gm of the sample was placed to it. The dish was then baked at 105°C for 24 hours before being cooled in desiccators and re-weighed.

Ash content was measured by using dry ashing in a muffle furnace set at 500°C for 8 hours, then placed in desiccators and weighed, and the ash content was calculated based on the procedures described by AOAC method no. 930.22).

Kjeldahl analyser (Kjeltec, Switzerland), model 8400 was used to determine crude protein using AOAC Method 950.36. The procedure of (AOAC Method 950.37) was used for the determination of crude fiber using sequential acid and alkali extractions.

Total Carbohydrate content was obtained by deducting the sum of the ash, proteins, crude fiber and fat contents from 100% [2].

The energy content (kcal/100 g) was determined using the equation shown below [2].

$$\text{Energy (kcal⁄100 g)} = [9 \times (\text{lipids\%}) + 4 \times (\text{proteins\%}) + 2 \times (\text{fiber\%}) + 4 \times (\text{carbohydrates})\ \%].$$

2.4. Minerals Content

According to the procedure described by Althwab et al., [5], mineral quantities in a diluted solution of the ashed samples were assessed using flame atomic absorption spectroscopy (3300 Perkin-Elmer).

2.5. Amino Acid Analysis

Samples were assayed for amino acid quantification through amino acid analyzer AAA400 (INGOS, Czech Republic) according to the method described by Mæhre et al. [25].

2.6. Identification of Fatty Acids Methyl Esters (FAMEs) by Gas-Liquid Chromatography

According to IUPAC [20, 21] recommendations, FAMEs were separated and measured. The quantity of the produced FAMEs was determined by gas chromatography (Varian model CP-3380) equipped with a flame ionization detector and a fused silica capillary column (100 m 0.25 mm i.d. 0.39 m 100% bonded cyanopropyl, Varian, EUA).

2.7. Sensory Properties

Sensory evaluation of date bars was carried out by 30 semi-trained panelists (22 females and 8 males), aged between 21 and 50 years old, were recruited among students and employees of department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah, Saudi Arabia. Prior to the sensorial evaluation, panelists were given instructions to ensure the reliability of the results. The sensory evaluation was performed in individual booths under white fluorescent lights at controlled room temperature, 25°C. The evaluation was carried out in terms of colour, flavor, taste, texture and general acceptance using the Hedonic scale 1-9 method, where 9 is strongly better 5 no better and at the same time I do not hate 1 I do not like at all. To avoid carryover flavors, panelists were given plain water to drink between samples. The sensory evaluation procedures were approved by the ethics Committee of the Auckland University of Technology study (AUTEC ethic application 16/340).

2.8. Statistical Analysis

In triplicate, a statistical analysis of the results was performed. Other than the findings of sensory evaluation (n=30). According to the methodology outlined by Gomez and Gomez [16], One-way analysis of variance (ANOVA) was used to assess the data with a significance level of 0.05, and Duncan's new multiple range tests were then used to define the statistically significant mean differences.

3. Results and Discussion

3.1. Chemical Composition and Mineral Nutrients of Date Bars Fortified with Various Levels of Germinated Flax Seeds (GFSs)

Proximate composition and mineral content of date bars fortified with various levels of germinated flax seeds (GFSs) are presented in Table 1. Moisture content of date bar samples ranged from 14.83 to 15.83. The results also show that increasing germinated flax seeds (GFSs) incorporation levels leads to significant decreases in the moisture content of the date bar samples. The lowest moisture content, 14.83% was recorded for date bars supplemented with 16% GFSs. However, the highest moisture level, 15.83%, was found in control date bar sample (100% date, without GFSs powder addition. These decreases in the moisture content of the fortified date bars may be due to the higher content of dry matter in the GFSs powder compared to the date paste.

Table 1. *Proximate composition and mineral nutrients of date bars fortified with various levels of germinated flax seeds (GFSs).*

Sample	SDFS 0%	SDFS 4%	SDFS 8%	SDFS 12%	SDFS 16%
Components (g/100 g dry weight basis)					
Moisture	$15.83^{a} \pm 0.83$	$15.6^{ab} \pm 0.60$	$15.3^{b} \pm 0.30$	$15.09^{bc} \pm 0.09$	$14.83^{c} \pm 0.83$
Fat	$0.45^{a} \pm 0.10$	$1.96^{ab} \pm 0.28$	$3.50^{abc} \pm 0.02$	$5.00^{abcd} \pm 0.32$	$6.61^{cbde} \pm 0.61$
Ash	$2.80^{a} \pm 0.80$	$2.86^{ab} \pm 0.86$	$2.91^{b} \pm 0.91$	$2.94^{b} \pm 0.94$	$2.99^{bc} \pm 0.99$
Protein	$2.35^{a} \pm 0.35$	$3.5^{ab} \pm 0.50$	$4.5^{bc} \pm 0.50$	$5.5^{cd} \pm 0.50$	$5.9^{cde} \pm 0.90$
Dietary fibres	$10.2^{a} \pm 0.20$	$10.75^{ab} \pm 0.89$	$11.30^{b} \pm 0.64$	$11.85^{bc} \pm 0.36$	12.41 ± 0.22
Carbohydrate	$84.2^{a} \pm 0.20$	$80.93^{ab} \pm 0.03$	$77.79^{bc} \pm 0.93$	$74.71^{cd} \pm 0.88$	$72.09^{de} \pm 0.28$
Energy	$370.65^{a} \pm 0.65$	$376.86^{b} \pm 0.36$	$383.26^{c} \pm 0.18$	$389.54^{d} \pm 0.13$	$396.27^{e} \pm 0.65$
Mineral analysis (mg/Kg)					
Na mg/kg	$53.764^{a} \pm 0.76$	$84.385^{b} \pm 0.38$	$139.16^{c} \pm 0.16$	$164.157^{d} \pm 0.15$	$182.56^{e} \pm 0.56$
Ca mg/kg	$629.16^{a} \pm 0.16$	$920.32^{b} \pm 0.32$	$923.959^{c} \pm 0.95$	$1002.392^{d} \pm 0.39$	$1004.12^{e} \pm 0.12$
K mg/kg	$10933^{a} \pm 1.00$	$10825.2^{b} \pm 0.20$	$10720.33^{c} \pm 0.33$	$10615.8^{d} \pm 0.80$	$10510.9^{e} \pm 0.90$
Mg mg/kg	$771.355^{a} \pm 0.35$	$960.764^{b} \pm 0.76$	$1023.382^{c} \pm 0.38$	$1171.199^{d} \pm 0.19$	$1234.78^{e} \pm 0.78$
V mg/kg	$724.608^{a} \pm 0.60$	$1027.012^{b} \pm 0.01$	$1119.393^{c} \pm 0.39$	$1476.253^{d} \pm 0.25$	$1643.647^{e} \pm 0.64$
Mn mg/kg	$3.77^{a} \pm 0.77$	$4.703^{ab} \pm 0.70$	$5.251^{abc} \pm 0.25$	$5.971^{bcd} \pm 0.97$	$6.324^{bcde} \pm 0.32$
Cu	$1.189^{a} \pm 0.18$	$1.616^{ab} \pm 0.61$	$1.999^{b} \pm 0.99$	$2.466^{c} \pm 0.46$	$2.746^{cd} \pm 0.74$
Fe mg/kg	$2.33^{a} \pm 0.33$	$3.69^{ab} \pm 0.69$	$5.47^{c} \pm 0.47$	$8.36^{d} \pm 0.36$	$10.99^{e} \pm 0.99$
Zn mg/kg	$1.33^{a} \pm 0.33$	$2.33^{ab} \pm 0.33$	$4.8^{c} \pm 0.80$	$5.39^{cd} \pm 0.39$	$8.0^{e} \pm 0.50$

As expected, the fat content of fortified date bars increased significantly (P>0.05) as GFSs substitution increased (Table 1). Date bar samples fortified with 16% GFS had the highest fat content (1.61%), while the control sample without GFSs powder addition had the lowest (0.45%) value. The increased fat content of supplemented date bars may be due to the high oil content of GFSs. About 41% of flax (*Linum usitatissimum* L.) is fat [29]. It contains 55% -Linolenic acid (ALA) and is a good source of omega-3s [15, 35]. 73% of the fatty acids in flaxseed oil are polyunsaturated, while 18% are monounsaturated [31]. The protein content of date bar samples ranged from 2.35% to 5.90%. Date bar samples fortified with

16% GFSs powder recorded the highest protein content (5.90%) value, while the lowest value was noted for unfortified samples without GFSs powder addition. Protein content of fortified date bar samples were increased with increase of GFSs powder in the blending proportion. Protein content of date bars fortified with 12 and 16% GFSs powder was about 2.34 and 2.51, times, respectively as high as that in unfortified samples without GFSs powder addition. (Table 1). Flaxseed grain and flaxseed paste contain about 21% and 34% protein, respectively, and this variation in protein content depends on genetic and environmental factors [11]. The ash content of date bar samples varied from 2.80 to 2.99%. The ash content was significantly higher ($p \leq 0.05$) in the fortified bars than in the control bars without GFSs powder addition. Date bars enriched with 12 and 16% GFSs had the highest (2.94 and 2.99%) ash content, respectively. Flax (*Linum usitatissimum* L.) serves as a good source of minerals [27]. The dietary fiber content of date bars ranged from 9.22 to 10.20%. The content of dietary fiber in date bars fortified with GFSs powder decreased significantly, from 10.20% for control sample without GFSs powder addition, to 9.89, 9.64, 9.36 and 9.22% for date bars supplemented with 4, 8, 12 and 16%, respectively.

Carbohydrate content of date bars varied from 80.28 to 8.20%. Substituting date paste with different levels of GFSs powder led to significant decreases in carbohydrate content of produced date bars. The incorporation of 12 and 16% GFSs powder into date bars contributed to significant decreases ($p < 0.05$) in the carbohydrate content (80.88 and 80.28%) compared to that of the control bar samples without GFSs powder addition (84.20%). Flaxseed has a low carbohydrate content. As a result, flax contributes very little to total carbohydrate intake [22].

Energy content of date bars ranged from 370.65 to 377.65 (kcal). Substituting date paste with different amounts of GFSs powder leads to significant increases ($p \leq 0.05$) in the energy content. Date bars supplemented with 4–16% GFSs powder had significantly higher energy values than the control date bars without GFSs additions. The highest energy contents (376.13 and 377.65 kcal) were noted for date bars enriched with 12 and 16% GFSs powder, respectively. In this regard, the total calories obtained from the energy bar increased significantly with increasing levels of flaxseed, the highest caloric value (397.95 kcal) obtained from bars containing 20% flaxseed and 45% sweeteners [28, 8].

As substitution levels increased, the mineral content of supplemented date bars increased significantly ($p \leq 0.05$). (Table 1). This finding could be attributed to the high mineral element content of GFSs powder. The highest concentration of micro- and microelements was noticed in date bars fortified with 12 and 16% GFSs powder, while the least values were found in control date bars without GFSs addition. Table 1 also shows that the concentration of Cu, Fe, Na, Zn, Ca, Mg, P and Mn in date bars enriched with 16% GFSs powder was about 2.3, 4.7, 3.39, 1.06, 1.59, 1.6, 2.26 and 1.67 fold greater, respectively, when compared to control date bars with no GFSs powder addition. Flax is a good source of minerals, particularly phosphorous (650 mg/100 g), magnesium (350-431 mg/100 g), calcium (236-250 mg/100 g), and sodium (27 mg/100 g) [27]. Among different foods, flax has the largest potassium concentration (5600-9200 mg/kg) [10].

3.2. Fatty Acid Profile of Date Bars

Table 2 shows the Fatty acid profile of date bars fortified with various levels of germinated flax seeds (GFSs). The content of saturated fatty acids was significantly ($P \leq 0.05$) different from control date bars and experimental, fortified date bars. The contents of saturated (SFA) fatty acids significantly decreased with increasing GFSs powder incorporation levels. Myristic and palmitic acids contents were significantly lower ($p \leq 0.05$) in the fortified date bats supplemented with GFSs powder than in the control with no added GFSs powder. The results also showed that the content of myristic and palmitic acids in date bars substituted with 16% GFSs powder were lower ($P < 0.05$) by 16.11 and 14.30%, respectively, when compared to control date bars without any addition of GFSs powder. Incorporation of GFSs powder into date paste at different levels caused significant increases in the content of mono-unsaturated fatty acids from 46.45 in unfortified date bars to 49.98, 51.21, 52.60 and 53.92 for those date bars supplemented with 4, 8, 12 and 16% of GFSs, respectively. The same trend was observed for the content of oleic acid.

Significant increases in the content of poly-unsaturated fatty acid were observed for date bars supplemented and enriched with various levels of GFSs powder. The content poly-unsaturated fatty acids in date bars enriched with 4, 8, 12 and 16% GFSs powder were higher ($P < 0.05$) by 16.91, 33.55, 50.66 and 85.68%, respectively, when compared to control date bars without any addition of GFSs powder. The incorporation of GFSs powder into date paste results in significant ($p \leq 0.05$) increases in the content of C18:2 n-6 (Linoleic acid). The content of C18:2 n-6 (Linoleic acid) in date bars enriched with 4, 8, 12 and 16% GFSs power were 1.02, 1.04, 1.06 and 1.14 times as great as that in control date bars without addition (Table).

The content of C18:3 n-3 (a-Linolenic acid) significantly increased from not-detectable level in control bars to 2.01, 3.97, 5.99 and 9.58% for those bars supplemented with 4, 8, 12 and 16% GFSs powder, respectively. A-linolenic acid (ALA), the most abundant w-3 fatty acid found in plants, is found in large amounts in flaxseed. Flaxseed is also low in saturated fats (9%), moderate in monounsaturated fats (18%), and high in polyunsaturated fats (73%). In addition, it is thought to be a source of a-Linolenic Acid (ALA), which has a higher bioavailability in oil than in milled seed and a higher bioavailability in both oil and milled seed than in whole seed [33].

Table 2. *Fatty acid profile of date bars fortified with various levels of germinated flax seeds (GFSs).*

Fatty acid	SDFS 0%	SDFS 4%	SDFS 8%	SDFS 12%	SDFS 16%
C14:0 (Myristic acid)	$6.95^{de} \pm 0.95$	$6.68^{d} \pm 0.68$	$6.38^{c} \pm 0.38$	$6.09^{b} \pm 0.09$	$5.83^{a} \pm 0.83$
C16:0 (Palmitic acid)	$25.65^{cde} \pm 0.65$	$24.79^{bcd} \pm 0.79$	$23.98^{abc} \pm 0.98$	$23.18^{ab} \pm 0.18$	$21.98^{a} \pm 0.98$
C18:0 (Stearic acid)	ND ± 0.00	$0.17^{cd} \pm 0.10$	$0.40^{bc} \pm 0.10$	$0.53^{ab} \pm 0.10$	$0.71^{a} \pm 0.10$
C20:0 (Arachidic acid)	ND	ND	ND	ND	ND
C22:0 (Behenic acid)	ND	ND	ND	ND	ND
Saturated fatty acid	$32.6^{de} \pm 0.60$	$31.64^{cd} \pm 0.64$	$30.76^{bc} \pm 0.76$	$29.8^{ab} \pm 0.80$	$28.52^{a} \pm 0.52$
C18:1-n9 (Oleic acid)	$53.92^{de} \pm 0.92$	$52.60^{cd} \pm 0.60$	$51.21^{bc} \pm 0.21$	$49.89^{b} \pm 0.89$	$46.25^{a} \pm 0.25$
C20:1 n-9 (Gadoleic acid)	ND ± 0.00	ND ± 0.00	ND ± 0.00	$0.09^{b} \pm 0.01$	$0.20^{a} \pm 0.10$
Mono-unsaturated fatty acid total	$53.92^{de} \pm 0.92$	$52.60^{cd} \pm 0.60$	$51.21^{bc} \pm 0.21$	$49.98^{b} \pm 0.98$	$46.45^{a} \pm 0.45$
C18:2 n-6 (Linoleic acid)	$13.48^{bcde} \pm 0.48$	$13.75^{bcd} \pm 0.75$	$14.06^{bc} \pm 0.06$	$14.32^{ab} \pm 0.32$	$15.45^{a} \pm 0.45$
C18:3 n-3 (a-Linolenic acid)	ND	$2.01^{d} \pm 0.01$	$3.97^{c} \pm 0.97$	$5.99^{b} \pm 0.99$	$9.58^{a} \pm 0.58$
Poly-unsaturated fatty acids total	$13.48^{e} \pm 0.48$	$15.76^{d} \pm 0.76$	$18.03^{c} \pm 0.03$	$20.31^{b} \pm 0.31$	$25.03^{a} \pm 0.03$
FAME total (%fat)	100	100	100	100	100

Table 3. *Amino acid composition (g/ 100 g protein) of date bars fortified with various levels of germinated flax seeds (GFSs).*

Amino acid	SDFS 0%	SDFS 4%	SDFS 8%	SDFS 12%	SDFS 16%
Isoleucine	1.85	2.16	2.28	2.39	2.51
Leucine	6.33	6.73	6.94	7.52	7.91
Lysine	2.50	2.59	2.65	2.72	3.16
Cystine	0.73	0.79	0.86	0.98	1.23
Methionine	0.83	1.02	1.42	1.54	1.78
Total sulfur amino acids	12.24	13.29	14.15	15.15	16.59
Tyrosine	1.39	1.59	1.66	1.72	1.77
Phenylalanine	3.87	4.25	4.42	4.68	4.89
Total aromatic amino acids	5.26	5.84	6.08	6.40	6.66
Threonine	1.25	1.37	1.49	1.58	1.77
Valine	1.95	2.02	2.12	2.21	2.46
Total essential amino acid	20.70	22.52	23.84	25.34	22.59
Histidine	1.67	1.73	1.68	1.70	1.96
Arginine	4.16	4.29	4.50	4.71	4.92
Aspartic acid	30.46	29.22	28.27	27.13	27.00
Glutamic acid	30.71	28.62	27.19	25.17	25.16
Serine	2.45	2.86	2.97	3.08	3.58
Proline	3.01	3.19	3.38	3.55	3.96
Glycine	3.07	3.68	3.96	4.50	5.11
Alanine	3.77	3.89	4.21	4.82	5.72
Total non-essential amino acids	79.30	77.48	76.16	74.66	77.41
PER	2.26	2.42	2.51	2.77	2.94

3.3. Amino Acid Composition (g/100 g Protein) of Date Bars Fortified with Various Levels of Germinated Flax Seeds (GFSs)

The amino acid compositions of control and supplemented date bars (g/100 g protein) are shown in Table 3. In general, the content of total essential amino acids for fortified date bars was significantly higher than that of the control bars (Table 3). The levels of isoleucine, leucine, total sulfur amino acids, total aromatic amino acids, as well as total essential amino acids were increased by adding various amounts of GFSs powder to date paste. Leucine, sulfur amino acids, and total aromatic amino acids were found in higher concentrations in the date bar samples fortified with various levels of GFSs powder compared to the reference pattern for children (1-2 years) [14]. However, it was found that the amounts of isoleucine, lysine, threonine, valine, and histidine in the supplemented and control date bars were lower than the FAO/WHO/UNU recommended limits [14]. These findings may be due to the fact that GFSs powder is considerable rich in arginine, aspartic and glutamic acids, opposite lysine, methionine and cysteine are limiting [36]. The major non-essential amino acid of date bars supplemented with various levels of GFSs powder were aspartic acid (27.0 – 30.46), glutamic acid (25.16 – 30.71), arginine (4.16 – 4.92), proline (3.01 – 3.96) alanine (3.77 – 5.72), glycine (3.07 – 5.11) and serine (2.45 – 3.58) respectively. It was observed that all date selections, cultivated in the United Arab Emirates contained high levels of glutamine and aspartic acid (>50% composition) as compared to other essential amino acids [34].

Protein efficiency ratio (PER) is a good indicator of assessing the quality of proteins [5]. PER ranged from 2.26 to 2.94. the lowest PER value was recorded for control date bars without addition of GFSs powder. Generally, addition of GFSs powder into date paste formula enhanced their protein efficiency ratio over the control sample without addition. The highest values (2.77 and 2.94) were recorded for those sample supplemented with 12 and 16% of GFSs powder. These findings are in agreement with Ogunronbi [30] and Hussain et al., [19] who stated that protein efficiency ratio (PER) of diets improved with the incorporation of flaxseed flour.

3.4. Sensory Evaluation of Date Bars Fortified with Various Levels of Germinated Flax Seeds (GFSs)

Table 4. *Sensory evaluation of date bars fortified with various levels of germinated flax seeds (GFSs).*

Sensory property	Date bar samples				
	SDFS 0%	**SDFS 4%**	**SDFS 8%**	**SDFS 12%**	**SDFS 16%**
Appearance	$8.80^{a} \pm 0.83$	$8.79^{a} \pm 0.64$	$8.70^{ab} \pm 0.62$	$7.93^{b} \pm 0.74$	$7.4^{bc} \pm 0.56$
Taste	$8.90^{a} \pm 0.81$	$8.87^{a} \pm 0.73$	$8.83^{a} \pm 0.66$	$7.85^{b} \pm 0.85$	$7.75^{b} \pm 0.63$
Aroma	$8.43^{a} \pm 0.45$	$8.41^{a} \pm 0.87$	$8.41^{a} \pm 0.66$	$7.82^{b} \pm 0.92$	$7.58^{bc} \pm 0.77$
Color	$8.27^{a} \pm 0.78$	$8.25^{a} \pm 0.71$	$8.25^{a} \pm 0.60$	$7.95^{ab} \pm 0.76$	$7.37^{b} \pm 0.72$
Overall acceptance	$8.60^{a} \pm 0.68$	$8.58^{a} \pm 0.59$	$8.54^{a} \pm 0.61$	$7.88^{ab} \pm 0.81$	$7.52^{b} \pm 0.63$

Consumer sensory satisfaction is one of many factors that determine a food product's marketing success [37]. The sensory properties of date bars supplemented with levels of GFSs powder are presented in Table 4. The appearance scores of bread samples ranged from 7.40 to 8.80. The control sample and date bars supplemented with 4.0% and 8.0% GFSs powder received the highest scores (8.80, 8.79 and 8.70). There were no significant differences in appearance scores between control bars and date bars containing 4% GFSs powder ($P > 0.05$). The addition of more GFSs powder resulted in a significant decrease in appearance scores. The samples with the lowest appearance values contained 16.0% GFSs powder. Taste scores of date bars varied from 7.75 to 8.90. No significant ($P \geq 0.05$) differences in taste scores were noted between control samples and date bars supplemented with 4 and 8% of GFSs powder, on the other hand, the taste values for date bars at higher fortification levels were significantly decreased. The lowest score (7.75) was noted for date bars fortified with 16% of GFSs powder. According to the sensorial results, date bars fortified with 0 and 4% of GFSs powder received the highest scores (8.43 and 8.41) for the odour, while date bars fortified with 12 and 16% of GFSs powder received the lowest scores (7.82 and 7.58). No significant ($P \leq 0.05$) differences in surface colour were noted between control date bars and those bars containing 4-8% GFSs powder. Higher additions (12 and 16%) of GFSs powder caused significant ($P \leq 0.05$) reductions in colour scores. Date bars with 4 and 8% GFSs powder and the control date bars scored the highest (8.54 -8.60) for overall acceptance. All date bar samples up to 8% GFSs powder supplementation did not show any statistically significant differences in overall acceptance ($p > 0.05$). On the other hand, date bars supplemented with 16 GFSs powder received the lowest score for overall acceptance (7.52).

4. Conclusion

Flaxseed (*Linum Usitatissimmum*) is a rich source of protein, unsaturated fatty acids as well as lignan component. Blending date paste with various levels of germinated flax seeds (GFSs). significantly improved the nutritional properties of the obtained date bars. Sensorial evaluation results indicated that no significant changes were observed in date bar samples supplemented with 4-8% of GFSs powder.

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