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Innovative use of date (*Phoenix dactylifera* L.) press cake in the food industry

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Abstract:
Introduction. Date press cake is a waste product of date juice making that can lead to potentially serious environmental problems if discarded in large amounts in open areas. Therefore, it needs to be utilized. Our study aimed to investigate the possibilities of using date press cake powder to formulate innovative ready-to-eat products – vegan biscuits and vegan protein bars.
Study objects and methods. The food products under study were subjected to a palatability test, a nutritional value evaluation, a texture profile analysis, and a scanning electron microscopy, as well as a microbiological assay performed during eight months of storage.
Results and discussion. The palatability test showed that the biscuits supplemented with 10% date press cake had the best acceptable preference, compared to control, 5 and 15% date press cake samples. Our innovative vegan protein bar scored highest in overall acceptability, flavor, taste, texture, and willingness to buy, compared to the commercial vegan protein bar. Overall, our study showed that both of our products were safe to consume within eight months. Additionally, our innovative protein bar and fortified biscuits had high proportions of the recommended dietary allowances for most nutrients for adolescents and athletes, especially for vegetarians.
Conclusion. Date press cake can be successfully used as a food ingredient to produce new formulations of vegan protein bars. Additionally, it can be used as an alternative ingredient to improve the nutritional quality of vegan biscuits.

Keywords: Date press cake, food industry, vegan products, biscuits, protein bars, chemical composition

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INTRODUCTION

Phoenix dactylifera L. is commonly known as Nakhel Al-Tamr in Arabian countries and as the date palm in English. A member of the genus Phoenix in the *Arecaceae* family, it grows in the hot desert regions of North Africa. In Egypt, dates have been an economically important food crop for thousands of years. According to the earliest records of predynastic Egypt (excavation of a vat in Hierakonpolis, Upper Egypt, 3450 BC), they were used as a beer sweetener. However, their cultivation started somewhat later than in Iraq (about 3000–2000 BC) [1, 2].

Egypt is at the top of the world's date-producing countries. In 2019, its production totaled 1.61 million tons, representing 16.41% of the world's production of 9.75 million tons [3]. Date fruits are a cheap and rich source of carbohydrates (70–80%) in the form of glucose and fructose, proteins, amino acids, and essential minerals (zinc, copper, selenium, potassium, calcium, magnesium, phosphorus, manganese, and iron), fiber, vitamins C and E, carotenoids, fatty acids, polyphenols, and flavonoids. Known as "emerging healthy foods" due to their health benefits, dates are commonly processed into juice, syrup, and paste, with many applications in other foods such as confectionary, bakery, and dairy products [2, 4–6]. As a result of agri-food production, large amounts of organic waste are produced as press cake that is mainly used as animal fodder and also in biofuel production [7].

Date press cake is a fibrous material that remains after date juice filtration. This by-product is a cause of disposal problems and environmental issues due to its bulky nature, high moisture, and carbohydrate content [2]. Date juicing accounts for 17–28% of date press cake that is dumped into open lands and drains or used as stock feed. However, it has been underutilized in the food industry, mainly due to the lack of technical knowledge about its nutritional value, health benefits, and possible effects on the quality of food products [2, 8]. In this context, we aimed to produce vegan biscuits

and vegan protein bars from date press cake and assess their quality and nutritional value.

STUDY OBJECTS AND METHODS

The objects of the study were date press cake powder in the production of innovative vegan protein bar and vegan biscuits (control sample and samples with 5, 10, and 15% of date press cake powder).

Materials. Date press cake was obtained from Al Tahhan Golden Dates Factory (New Valley Governorate, Egypt). Crisp rice (rice flour-corn flour-wheat flour 72%-calcium carbonate) was a gift from Caker Food Industries (New Damietta City, Egypt). Other dry ingredients and corn oil for our innovative vegan protein bars and vegan biscuits were purchased from the Metro Market (Egypt). The control was a commercial protein bar (Go Food Bar) (dates, almonds, cashew, cocoa) purchased from the Advanced Sport Nutrition Company (Cairo, Egypt). All the chemicals and equipment used in this research were of analytical grade.

Technological methods. ***Processing methods. Production of date press cake powder.*** After juicing fully matured Saidi dates, press cake was ground in a laboratory grinder, sieved through a 70 mesh sieve to obtain particles of 210 microns, and stored in sealed polyethylene bags at –18°C for technology application, as described in [6].

Preparation of vegan protein bars. Our innovative vegan protein bars were prepared in the following stages:
– good quality dried peeled split fava beans were rinsed, soaked in water for 12–13 h, boiled in plenty of water for 4 min until tender but not mushy; then drained, tossed in the oil, and spread out in a single layer on a baking sheet, and roasted at 185°C until golden and crispy;
– yellow split chickpeas and roasted split fava beans were individually milled in a laboratory mill (JKA-Labora technic, Janke and Kunkel Type: MFC, Germany);
– oat was roasted in an aluminum pan at 140°C in a low flame to get roasted aroma;
– 10 g of date press cake powder was mixed with 40 g of other dried ingredients (yellow split chickpeas, roasted split fava beans, instant coffee, oat, salt, coconut powder, crisp rice);
– glucose syrup (26 g) and molasses (24 g) were heated to 70°C for 2.5 min, mixed well with all dried ingredients and 2 mL of oil, molded into a bar shape (8×2.3×1.5 cm), and finally packaged in airtight polyethylene bags (HDPE) before measurements;
– the samples were stored at room temperature 25 ± 5°C for 8 months for microbiological assays.

Preparation of vegan biscuits. Control biscuits dough was prepared using 100 g of wheat flour (72% extraction), 25 g powdered sugar, 22 g corn oil, 1 g sodium chloride, 1 g ammonium bicarbonate, and 28 g water, as described in [9]. Experimental samples contained 5, 10, or 15% of date press cake powder instead. Biscuits were prepared in the following stages:
– sugar was mixed with corn oil and creamed intensively (speed 5) for 3 min in a KitchenAid mixer;
– wheat flour (72% extraction), sodium chloride, ammonium bicarbonate, and water were added to prepare dough;
– the dough was manually mixed for 15 min into a uniform smooth paste [10];
– biscuits were formed and baked in an oven at 180°C for about 25 min;
– the biscuits were cooled at room temperature 25 ± 5°C, packaged in airtight polyethylene bags before measurements, and stored at room temperature for eight months for microbiological assays.

Palatability test. Palatability evaluation of our products was carried out by ten experienced panelists from the Food Technology Research Institute (Agricultural Research Center, Giza, Egypt) according to the method described in [11]. Then, 30 consumers from the local market who were willing to buy the products were also tested according to [12].

Evaluation of the nutritional value. The samples were analyzed for moisture, ash, protein, crude fiber, and crude fat on a dry weight basis according to the standard procedures recommended by [13] while total carbohydrates were calculated by difference. %Available carbohydrates (on dry basis) = 100 – (%Ash + %Fat + %Protein + %Fiber), as mentioned by [15]. Energy (Kcal) was calculated by the formula of [14] as follows: Energy (Kcal) = [Protein (g)×4] + [Carbohydrate (g)×4] + [Fat (g)×9]. Minerals, i.e., calcium (Ca), iron (Fe), Magnesium (Mg), Potassium (K), Manganese (Mn), and Zinc (Zn) were determined using an Atomic Absorption Spectrophotometer (3300 Perkin-Elme), as described in [13].

Texture profile analysis. Texture properties of our products, such as chewiness, gumminess, springiness, cohesiveness, and hardness, were estimated using a CT3 Texture Analyzer (Version 2.1, 10 000 Gram unit, Brookfield, Engineering Laboratories, Inc., USA), according to the method of [16].

Scanning electron microscopy. Scanning electron microscopy (SEM) was used to visualize the microstructure of the bars, as described by [17].

Microbiological analysis. Total bacterial, yeast, and mold counts were carried out during different storage periods according to [18].

Statistical analysis. The statistical analysis was performed using SPSS One-Way ANOVA, version 22 (IBM Corp.) released in 2013. Data were treated as a complete randomization design according to [19]. Multiple comparisons were carried out applying the Duncan test. The significance level was $P < 0.05$.

RESULTS AND DISCUSSION

Chemical composition and minerals content. The chemical composition and mineral content of Saidi date press cake are shown in Table 1. As we can see, Saidi date press cake contained 6.11% moisture, 5.12% fat, 7.4% protein, 12.38% crude fiber, 2.78% ash, and 66.21% carbohydrates. Of the six minerals determined in the sample, Mg had the highest content, while Mn had the

Table 1 Chemical composition (dry weight) and mineral content of Saidi date press cake powder

Parameters	Content
Moisture, %	6.11
Protein, %	7.4
Crude fiber, %	12.38
Fat, %	5.12
Ash, %	2.78
Total carbohydrates, %	66.21
Minerals, mg/kg:	
Mn	10.9
Ca	502
Fe	78.45
Zn	19.2
Mg	625
K	27.4

Table 2 Sensory evaluation and willingness to buy vegan protein bars with data press cake powder

Parameters	Samples	
	Commercial bar	Innovative bar
Color	9.80 ± 0.95^{a}	7.14 ± 0.72^{b}
Flavor	6.95 ± 0.30^{b}	8.35 ± 0.23^{a}
Taste	7.73 ± 0.21^{b}	9.30 ± 0.20^{a}
Texture	7.83 ± 0.16^{b}	8.40 ± 0.20^{a}
Overall acceptability	8.18 ± 0.45^{b}	9.13 ± 0.20^{a}
Willingness to buy the vegan protein bar samples:		
Yes	25.00 ± 01.00^{b}	27.30 ± 0.58^{a}
No	5.0 ± 1.0^{a}	2.66 ± 0.57^{b}

[a] and [b]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same row

Table 3 Sensory preference test and willingness to buy biscuit with 10% of date press cake powder

Parameters	Samples			
	Control	5% DPC	10% DPC	15% DPC
Color	6.30 ± 0.71^{b}	8.06 ± 0.07^{a}	9.02 ± 0.15^{a}	5.40 ± 0.23^{b}
Flavor	7.18 ± 0.28^{b}	8.20 ± 0.23^{a}	8.68 ± 0.14^{a}	5.21 ± 0.26^{c}
Taste	7.54 ± 0.06^{c}	8.08 ± 0.08^{b}	9.07 ± 0.12^{a}	4.67 ± 0.18^{d}
Texture	7.96 ± 0.89^{a}	8.51 ± 0.10^{a}	8.17 ± 0.11^{a}	4.07 ± 0.22^{b}
Overall acceptability	7.73 ± 0.17^{c}	8.16 ± 0.18^{b}	8.86 ± 0.05^{a}	4.17 ± 0.15^{d}
Willingness to buy the vegan biscuit samples				
Samples	Control	5% DPC	10% DPC	15% DPC
Yes	20.20 ± 0.59^{c}	23.20 ± 0.51^{b}	27.00 ± 0.33^{a}	13.90 ± 0.86^{d}
No	9.80 ± 0.59^{b}	6.80 ± 0.51^{c}	3.00 ± 0.33^{d}	16.10 ± 0.86^{a}

[a–d]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same row. DPC – date press cake.

lowest content. These findings are in agreement with those reported by [2], who found that Shahani date press cake contained an average of 4.92% fat and 11.74% crude fiber, while Na, K, Cu, Zn, and Fe amounted to 2.05, 29.93, 9.06, 19.72, and 80.75 mg/kg, respectively.

Palatability tests. ***Vegan protein bars.*** Sensory evaluation is an important indicator of potential consumer palatability. Table 2 presents the sensory scores for the tested vegan protein bars, commercial and innovative. As we can see, the innovative protein bar obtained a significantly higher sensory score in flavor, taste, texture, and overall acceptability, while the commercial protein bar scored higher in color, which might be due to chocolate. However, the willingness to buy the vegan protein bars was significantly higher for the innovative samples (27.3 ± 0.58) than the commercial samples (25.00 ± 01.0), with 91 and 83.33% of the respondents, respectively.

Vegan biscuits. A preference experiment was designed to select the best ratio of raw materials for vegan biscuits. According to the palatability results (Table 3), the control biscuits and fortified biscuits with 5 and 10% date press cake powder (DPC) scored higher in color, flavor, taste, texture, and overall acceptability. The sample with 10% DPC and 90% wheat flour received the most significant scores in taste, and overall palatability. Additionally, most of the respondents (90%) were significantly willing to buy this sample, compared to the other samples. Since the 10% sample showed the best preference, we selected it for our further studies.

Nutritive values of investigated products. ***Vegan protein bars.*** The nutritive values of commercial and innovative vegan protein bars are shown in Table 4. We found that the innovative bar scored significantly higher in protein, fiber, ash, and minerals, compared to the commercial bar. However, fat, available carbohydrates, energy, and moisture were significantly lower. Snack bars with high energy are consumed by top athletes to improve their performance. Therefore, the commercial and innovative bars could be introduced in their diet, as described by [20].

The recommended dietary allowances (RDA) given by the Indian Council of Medical Research (ICMR) for female and male athletes, respectively, are as follows: energy 3600 and 4500 Kcal/day, protein 82.5 and 120 g/d, fat 30 and 40 g/d, carbohydrates 585 and 731.25 g/d, iron 21 and 17 mg/d, and calcium 600 mg/d for females and males, as reported by [21, 22]. Our

Table 4 Nutritive values of innovative protein bar vs. commercial protein bar

Parameters	Vegan protein bars	
	Commercial bar	Innovative bar
Moisture, %	13.46 ± 0.17[a]	6.89 ± 0.38[b]
Protein, %	12.30 ± 0.17[b]	19.32 ± 1.24[a]
Fat, %	8.26 ± 0.24[a]	6.25 ± 0.21[b]
Fiber, %	0.67 ± 0.06[b]	2.10 ± 0.07[a]
Ash, %	1.21 ± 0.05[b]	1.80 ± 0.07[a]
Available carbohydrates, %	77.50 ± 1.17[a]	70.60 ± 1.19[b]
Energy, Kcal/100 g	433.50 ± 2.05[a]	416.10 ± 4.87[b]
Iron, mg/100 g	1.46 ± 0.08[b]	2.50 ± 0.15[a]
Zinc, mg/100 g	1.30 ± 0.08[b]	2.10 ± 0.11[a]
Calcium, mg/100 g	36.00 ± 2.40[b]	45.70 ± 2.21[a]
Potassium, mg/100 g	199.66 ± 1.20[b]	214.66 ± 1.76[a]
Mg, mg/100 g	19.30 ± 0.41[b]	28.18 ± 0.61[a]
Mn, mg/100 g	1.34 ± 0.06[b]	1.83 ± 0.04[a]

[a] and [b]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same row

Table 5 Nutritive values for vegan biscuits fortified with 10% of date press cake powder vs. control vegan biscuits

Parameters	Vegan biscuits	
	Control	10% DPC
Moisture, %	3.89 ± 0.11[b]	4.76 ± 0.09[a]
Protein, %	7.40 ± 0.18[b]	8.70 ± 0.11[a]
Fat, %	11.72 ± 0.19[a]	9.49 ± 0.24[b]
Fiber, %	0.90 ± 0.01[b]	2.53 ± 0.14[a]
Ash, %	1.83 ± 0.06[a]	1.16 ± 0.12[b]
Available carbohydrates, %	78.15 ± 0.38[a]	78.12 ± 0.66[a]
Energy, Kcal/100 g	447.50 ± 3.60[a]	432.80 ± 2.47[a]
Iron, mg/100g	1.86 ± 0.03[b]	2.90 ± 0.24[a]
Zinc, mg/100g	0.51 ± 0.11[b]	1.21 ± 0.02[a]
Calcium, mg/100g	16.22 ± 0.56[b]	22.51 ± 1.73[a]
Potassium, mg/100g	135.66 ± 7.20[b]	158.66 ± 3.17[a]
Mg, mg/100g	14.60 ± 0.69[b]	19.50 ± 0.84[a]
Mn, mg/100g	0.37 ± 0.03[b]	1.67 ± 0.22[a]

[a] and [b]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same row. DPC – date press cake.

female and male athletes, respectively: energy 11.55 and 9.24%, protein 23.46 and 16.13%, fat 20.8 and 15.6%, carbohydrates 12.06 and 9.65%, iron 11.90 and 14.70%, and calcium 7.6% for both. The results for 100 g of the commercial bar were as follows: energy 12.04 and 9.63%, protein 14.90 and 10.25%, fat 27.5 and 20.7%, carbohydrates 13.24 and 10.59%, iron 6.95 and 8.59%, and calcium 6.0% for both females and males. The intake of total calories, carbohydrates, proteins and fats were normal in female athletes but less than RDAs [23].

Adolescence is a transition period between childhood and adulthood from 13 to 17 years of age. Therefore, adolescents need additional calories, protein, calcium, and iron [24]. According to [25], the recommended intake for female and male adolescents, respectively, is as follows: energy 2200 and 2900 Kcal/d, protein 46 and 58 g/d, iron 15 and 10 mg/d, calcium 1200 mg/d for both sexes, and zinc 12 and 15 mg/d. We found that 100 g of the innovative bar covered the recommended intake at the following levels in females and males, respectively: energy 18.91 and 14.34%, protein 42.08 and 33.30%, iron 16.67 and 25.00%, calcium 3.80% for both sexes, and zinc 17.5 and 14.0%. The results for 100 g of the commercial bar were as follows: energy 19.70 and 14.95%, protein 26.73 and 21.20%, iron 9.7 and 14.6%, calcium 3.0% for both sexes, and zinc 10.33 and 8.66%.

Vegan biscuits. The nutritive values for the vegan biscuits fortified with 10% DPC and the control vegan biscuits are given in Table 5. The 10% DPC sample contained higher moisture, protein, fiber, iron, zinc, calcium, potassium, magnesium, and manganese but lower ash and fat. In addition, 100 g of the 10% biscuits met the daily requirement in female and male adolescents, respectively, for energy 19.67 and 14.92%, protein 18.91 and 15.00%, iron 19.33 and 29.00%, calcium 1.88% for both sexes, and zinc 10.08 and 8.06%. The results for 100 g of the control biscuits were as follows: energy 20.34 and 15.43%, protein 16.08 and 12.75%, iron 12.4 and 18.6%, calcium 1.35% for both sexes, and zinc 4.25 and 3.40%, as reported by [25].

We found that a 100 g serving of the 10% DPC biscuits provided a substantial proportion of the RDAs established by the ICMR for female and male athletes, respectively, in relation to energy 12.02 and 9.62%, carbohydrates 13.35 and 10.68%, fat 31.63 and 23.73%, protein 10.54 and 7.25%, iron 13.80 and 17.05%, and calcium 3.75% for both sexes. The control biscuits (100 g) showed the following values: energy 12.43 and 9.94%, carbohydrates 13.36 and 10.68%, protein 8.97 and 6.16%, fat 39.06 and 29.30%, iron 8.86 and 10.94%, and calcium 2.7% for both sexes, according to [22].

Texture profile analysis and scanning electron microscopy. ***Vegan protein bars.*** Texture profile

Table 6 Texture profile of vegan protein bars (mean ± SE)

Samples	Texture profile analysis				
	Chewiness, mJ	Gumminess, N	Springiness, mm	Cohesiveness, mm	Hardness, N
Commercial bar	32.63 ± 0.81[a]	17.42 ± 0.54[a]	1.10 ± 0.32[a]	22.40 ± 1.93[b]	35.54 ± 1.00[b]
Innovative bar	25.97 ± 1.54[b]	14.33 ± 0.42[b]	1.96 ± 0.05[a]	31.73 ± 1.68[a]	43.58 ± 2.28[a]

[a] and [b]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same column

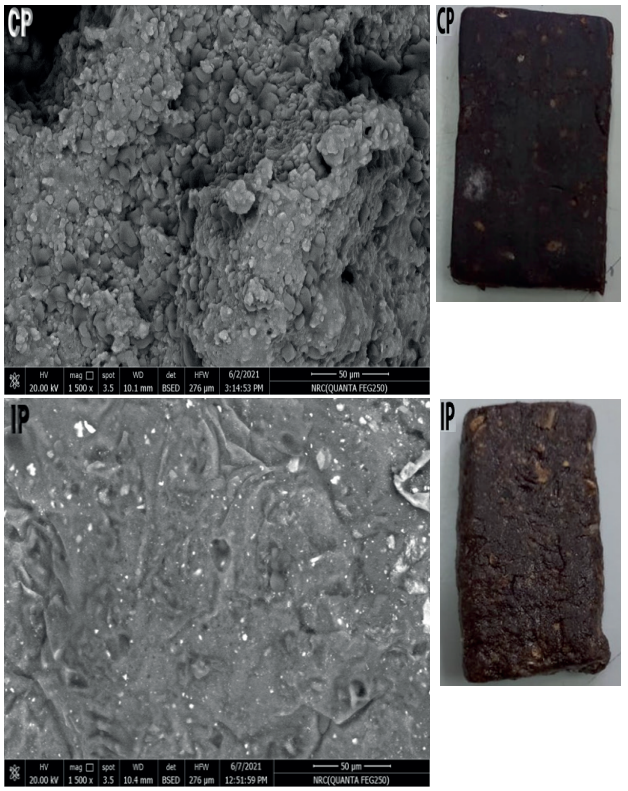

Figure 1 Scanning electron microscopy images for experimental vegan protein bars. IP – innovative protein bar. CP – commercial protein bar. Magnifications of 1500×

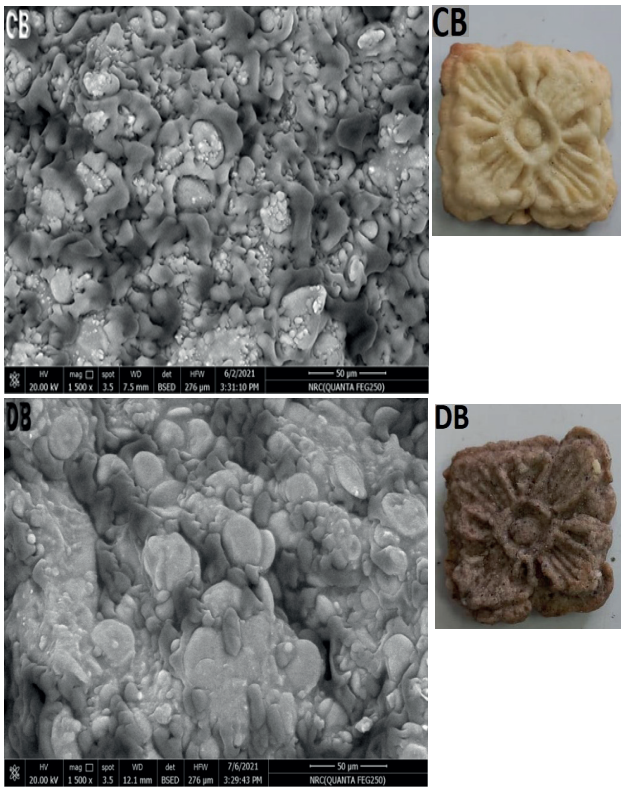

Figure 2 Scanning electron microscopy images of experimental vegan biscuits. DB – 10% DPC-fortified biscuits. CB – Control biscuits. Magnifications of 1500×

analysis is another important measure of a food product's overall quality and consumer acceptability. The results of texture analysis of the vegan protein bars (commercial and innovative) are shown in Table 6. We found that the DPC-fortified innovative bar showed significantly higher ($P \leq 0.05$) hardness and cohesiveness values, but significantly lower gumminess and chewiness values, compared to the commercial bar, which contained date and was coated with chocolate. The increased hardness of our innovative bars may be due to the migration of moisture between carbohydrates (such as starches, pectins, sugars, and maltodextrin) and proteins, or due to their protein content increase (19.32%), as shown in Table 4 [26]. However, the hardness of high-protein bars is quite high. It increases with the addition of protein and is characterized by a large variety of parameters [27].

The microstructures of cross-sectional areas of the commercial and innovative protein bars are shown in Fig. 1. As we can see, the innovative bar had a wavy structure, with few cavities and air pores, and relatively high hardness, while the commercial bar had a round structure with a number of cavities and air pores. A formation of large protein clusters (agglomerates) was probably the cause of the increased hardness of the innovative bar [27]. The formation of characteristic agglomerates in the innovative bar might be due to the presence of lectin sources in its ingredients. Lectins are glycoproteins known for their aggregation and high specificity binding with carbohydrates without initiating a modification through associated enzymatic activity. This leads to the formation of compact and hard structures, accounting for high hardness, factorability, and adhesiveness [27, 28].

Table 7 Texture profile of vegan biscuits (mean ± SE)

Treatment	Physical properties				
	Chewiness, mJ	Gumminess, N	Springiness, mm	Cohesiveness, mm	Hardness, N
Control biscuits	65.93 ± 1.74[a]	28.33 ± 0.88[a]	3.25 ± 0.07[a]	0.55 ± 0.06[b]	35.05 ± 4.04[b]
Biscuits fortified with 10% of date press cake powder	42.68 ± 1.24[b]	16.44 ± 1.26[b]	2.40 ± 0.04[b]	1.20 ± 0.08[a]	56.20 ± 3.53[a]

[a] and [b]: If there is no significant difference ($P > 0.05$) between any two means, they have the same superscript letter within the same column

Table 8 Total bacterial, yeast and mold count (CFU/g) of 10% date press cake vegan biscuits and innovative vegan protein bar during storage at room temperature 25 ± 5°C

Total bacterial count						
Storage period, month	Vegan biscuits				Innovative vegan protein bar	
	Control		10% DPC			
	Number of cells, CFU/g	Log survivor	Number of cells, CFU/g	Log survivor	Number of cells, CFU/g	Log survivor
0	n.d.	–	n.d.	–	n.d.	–
2	1.6×10^2	2.20	1.1×10^2	2.04	n.d.	–
4	3.7×10^2	2.57	2.2×10^2	2.34	n.d.	–
6	5.0×10^2	2.70	3.9×10^2	2.59	6.0×10	1.78
8	7.0×10^2	2.85	4.0×10^2	2.60	9.0×10	1.95
Yeast and mold count						
Storage period, month	Vegan biscuits				Innovative vegan protein bar	
	Control		10% DPC			
	Number of cells, CFU/g	Log survivor	Number of cells, CFU/g	Log survivor	Number of cells, CFU/g	Log survivor
0	n.d.	–	n.d.	–	n.d.	–
2	n.d.	–	n.d.	–	n.d.	–
4	4.0×10	1.60	n.d.	–	n.d.	–
6	6.0×10	1.78	3.0×10	1.48	n.d.	–
8	2.6×10^2	2.41	1.1×10^2	2.04	2.0×10	1.30

*n.d. – not detected

Vegan biscuits. Biscuits are a type of bakery products with minimal mixing and low water activity. Short dough has minimal, if any, gluten development that results in the production of smaller biscuits. In our study, the addition of date press cake caused a significant increase ($P \leq 0.05$) in hardness and cohesiveness, as well as a significant decrease in springiness, gumminess, and chewiness, compared to the control sample. This was due to the effect of fibers that have high water and oil adsorption capacity [29].

Majzoobi *et al.* indicated that date press cake can promote starch retrogradation and protein aggregation, which can also account for the increased hardness and reduced springiness [6]. So, the increase in biscuits hardness can be attributed to the dilution and weakness of the gluten network caused by data press cake.

The Scanning Electron Micrograph showed the effect of date press cake fibers on cross-sectional areas of the control biscuits and the DPC-fortified biscuits. As we can see in Fig. 2, their structures were slightly different. The cross-sectional area of the control biscuits showed gaps and air cells, compared to that of the fortified sample. Also, we found that the fortified vegan biscuits had an increased cell size, as well as bulged and thicker cell walls.

Our results agreed with those of Dar *et al.* who studied carrot pomace powder-based extrudates [30]. They reported that as the concentration of powder increased, the size of air bubbles and moisture droplets became smaller, resulting in a tough product. They also found that the presence of additives such as fiber and sugar had a pronounced effect on the expansion of cookies.

In another study, supplementing cookies with date and peach powder (2, 4, and 6 %) increased cell size and caused a rough structure with fractured fibers and starch granules that got reoriented to shape the cookies [31]. At a 6% supplementation, the cell walls became bulged and thicker.

Microbiological assay. Table 8 illustrates various microorganisms (total bacteria count, yeast and mold count, CFU/g) in the vegan biscuits and innovative vegan protein bars partially supplemented with date press cake powder over a storage period of 8 months. We did not detect any bacteria in the biscuits samples in the zero time since high baking temperatures killed all the microorganisms. After 2 and 8 months of storage, the bacterial counts were 1.6×10^2 and 7.0×10^2 CFU/g for the control biscuits, respectively, and 1.1×10^2 and 4.0×10^2 CFU/g for the DPC-fortified biscuits, respectively.

Yeasts and molds were not detected after 2 months of storage for the control and after 4 months of storage for the fortified samples. The yeast and mold counts for the control biscuits were 4.0×10 and 2.6×10^2 CFU/g after 4 and 8 months of storage, respectively, whereas for the fortified biscuits they amounted to 3.0×10 and 1.1×10^2 CFU/g after 6 and 8 months of storage, respectively. Microbial contamination can be caused by the worker's contaminated hands during handling or by increased temperatures during storage [32]. Our results were very low compared to the WHO Standard (1994), which established the maximum permissible limits for total plate count and yeast and mold count to be 2.0×10^5 and $< 1.0\times10^4$ CFU/g, respectively, in baked products (cake, bread, and

biscuits) [33]. Thus, our biscuits had a lower microbial profile and therefore were safe to consume.

The shelf life analysis of the innovative vegan protein bar detected no bacteria after 2 and 4 months. Bacterial growth was detected after 6 months, while yeast and mold were detected after 8 months of storage at room temperature 25 ± 5°C. This means that the quality of our innovative bars was quite stable and they may be considered safe to consume. Our findings were in agreement with Pratiwi *et al*. who indicated that formulated products were safe for consumption if yeast and mold were lower than 10^2 CFU/g and total bacterial count was lower than 1×10^3 CFU/g, as based on the Thai Community Product Standard (TCPS 709/2004) [34].

CONCLUSION

Our study clearly showed that using date press cake powder to produce vegan biscuits and protein bars is practical, economic, and healthy since these products have a high nutritional value and technological quality. They contained high proportions of the recommended dietary allowances for most of the studied nutrients for adolescents and athletes and are especially useful for vegetarians.

CONFLICT OF INTEREST

The author declares no conflict of interest regarding the publication of this research.

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