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Development and nutritional characterization of nutrients enriched food bars

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Abstract

The objective of this research was to determine the effects of minerals, fennel and carrots juice on the physico-chemical properties of food bars during storage.Texture in terms of hardness values were from 149.24 to 341.33g. FB_0 had less hardness (149.24 g) and it gradually increased towards FB_2 (341.33 g) and during storage of 90 days. Same trend was observed for factorability. The lowest water activity (0.555) was observed in FB_0 and the highest (0.564) in FB_4. The water activity during storage decreased from 0.572 to 0.550 after 90 days. The minimum moisture content was observed in FB_0 and the highest in FB_4. During storage, moisture content decreased and non-significant change in protein content and fiber content was observed. These food bars provide energy ranged from 372.93 to 389.82 Kcal/100g. The maximum in-vitro protein digestibility values are recorded in FB_2 (87.41%) and FB_4 (87.30%) while, the minimum (85.78%) in control bar (EF_0) indicating that fennel seed saturated with carrot juice increased the in-vitro protein digestibility and similarly improves starch digestibility. Minerals content increased significantly with the addition of fennel seeds and spinach ash in food bars, while the minimum minerals content has been observed in control food bar (FB_0) having no added mineral source.

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Introduction

Malnutrition and under-nutrition of school going children are becoming a global issue related to public health. The number of overweight and stunted children is more than 200 million and there would be one billion mentally or physically impaired children by 2020, if it remained unchecked. It is a major cause of three hundred thousand deaths in a year directly and an indirect cause for half of the total deaths of young children (De Onis *et al*., 2012). Among those who survive, many suffer with chronic malnutrition which results in devastating and irreversible damage. This is very common problem particularly in Asian and African countries. When nutritious and hygienic food is not available for children, their brain and body both cannot grow at the proper rate and they have to face difficulties in learning and studying. Malnutrition can occur due to deficiency of macronutrients such as carbohydrates, proteins and fats causing protein energy malnutrition and due to micronutrients deficiency such as minerals, vitamins and electrolytes which cause deficiency related to a particular micronutrient (Mary and Devi, 2016).

Usually school going children prefer junk food available in the market during their school session. Except only a few products, most of the junk food is not suitable for fulfilling child's requirements and results in deficiency of food nutrients, especially micronutrients. More than 20% people fall below poverty line in Pakistan (if per adult income is taken as Rs. 200 per day).

They cannot afford school expenses of their child and resultantly children buy unhygienic and unsuitable junk food products falling in their economic range which ultimately results in worst and long lasting health consequences. There is a great space and need for the introduction of healthy, organic and economic food which fulfill mid-day energy requirements of children without leaving bad effects on their health (Raulio *et al*., 2010).

People at work place feel hunger almost when half of their working time is passed. They go for canteen, packed food as well as to the restaurants, with varying ratio of preference between male and female workers. Restaurants meals usually contain higher amount of saturated fats, other fats and calories as compared to home-cooked meals. Office workers eat preferably those foods which they find in their immediate approach. It is evident from a research in which office workers reduced the consumption of chocolates, when chelates were removed from office candy dish (Wansink *et al.,* 2006).

Food bar is concentrated food product that is classified as confectionary or snack product having high nutritional value with longer shelf life. Increased consumption of fruits is considered as major factor in reduction of chronic diseases (Joshipura *et al*., 2001). These fruit bars provide health due to their antioxidant, fiber and protein contents (Nadeem *et al*., 2012). Nutritious products can meet the requirements of people by including cereals in food bars (Maurer *et al.,* 2005). Now consumer demand is increasing for convenient, natural and healthy food that's why many attempts are being made to improve nutritional value of snack food. Snack bars are convenient and popular foods therefore these are considered as ideal food format that provide fruit derived nutrients (Munir *et al*., 2016).

In the current scenario, development of a nutritious food bar; blending fennels saturated with carrot juice with cereals and nuts with mineral source is an acceptable and nutritious alternative to other snacks. The low moisture content of food bars gives the bar suitable matrix and thereby increasing storability. Different nutritional properties of fennel, carrots, spinach, nuts and cereals may be complementary to each other. Food bars would not only fulfill the nutritional requirements, but also produces a healthy product for all ages.

The use of fennels, carrots and spinach in food bars may be attractive to the consumers as a positive alternative to conventionally produced plain snacks. This project was designed to produce a food bars with pro-vitamin A activity and rich in minerals.

Materials and methods

The study was conducted at Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan.

Raw materials

Commercially available corn, carrots, spinach, almonds, fennel, sugar, liquid glucose, salt, butter and milk powder were purchased from the local market of Sargodha. Chemicals for analyses were purchased from Sigma Aldrich (Seelze, Germany) and Lab-Scan (Dublin, Ireland) available in the local market.

Preparation of food bars

Food bars were prepared according to the method described by Nadeem *et al.* (2012).

Pre-treatment of raw materials

Spinach leaves were washed and dried in oven and then converted into ash in Muffle Furnace at 105°C for 5 hours. Corn grains were roasted and ground to make flour. Carrots were washed and juice was extracted. Fennel was cleaned for impurities and dipped in carrot juice and were put in oven for 24 hours at 60°C for the removal of moisture. The obtained dried matter of fennel saturated with carrot juice was ground to make powder. Almonds were crushed.

Procedure for development of food bars

After the raw material was prepared, butter was heated in a pan and milk powder dissolved in water was added to it to make a mixture with fine texture. After cooking of 10 minutes, corn floor and minute quantity of salt was added slowly with continued mixing. After that, spinach ash, fennel powder saturated with carrot juice, almonds, sugar powder and liquid glucose were added and cooked until suitable consistency for bars was obtained. The prepared material was shifted to the sheeting and cutting table. Stainless steel roller was used for sheeting of about 1cm thickness and cutting was done with the help of cutters, keeping the width of bars 2.5 cm and length 7cm. Each bar having approximate weight of 25±2 g was packed carefully in aluminum foil. The quantity of fennel powder saturated with carrot juice was used according to the treatments plan (Table 2), while other ingredients were kept constant (Table 1).

Physico-chemical analyses of food bars

Texture analysis

Texture analysis of bars was determined with the help of Texture Analyser (model TA_XT Plus, Stable Microsystems, Surrey, UK) with 5 Kg load cell according to the method as described by Rehman and Al-Farsi (2005) with minor modifications.

Water activity (aw)

Water activity in bars was determined by the standard water activity meter method (AOAC, 2000) using an electronic hygropalm Water Activity Meter (Model. Aw-Win, Rotronic, equipped with a Karl-Fast probe). Hygropalm water activity meter is a portable humidity temperature indicator, having 9 volts battery. 5g sample of food bar was placed in sample cup and reading on display was noted. The procedure was repeated thrice.

Proximate composition

Proximate composition such as moisture, ash, crude protein, and crude fat and crude fiber of bars was determined and expressed on dry matter basis (AOAC, 2006).

Gross energy of food bars

Gross energy value of food bars was determined by the use of standard factors of 9.0, 3.75 and 4.0 kcal/g for lipids, proteins and carbohydrates respectively, the energy contents were summarized to provide gross energy of the bar samples (Livesey, 1990).

Minerals analyses

Food bar samples were analyzed for mineral profile according to the procedures as described in AOAC (2006).

In vitro starch digestibility (IVSD)

The *in vitro* starch digestibility (IVSD) was assayed by employing porcine pancreatic amylase (Singh *et* *al.,* 1982). Porcine pancreatic amylase (EC 3.2.1.1, 790 units/mg protein; catalog No. A6255, Sigma) was used to give final concentration 0.4mg/mL. 1mg of maltose is released from starch by treating one unit of amylase in 3min at pH 6.9 and temperature 20°C. In brief, 50mg bar sample was incubated after adding 0.5mL pancreatic amylase solution at 20°C for 2h. After the incubation, 2mL 3,5-dinitrosalicyclic acid reagent was added and the mixture was boiled for 5min. After cooling, the absorbance of the filtered solution was measured at 550nm with maltose as the standard.

The values of starch digestibility were expressed as milligrams of maltose released per gram of dry sample (Chau and Cheung, 1997).

In vitro protein digestibility (IVPD)

The *in vitro* protein digestibility (IVPD) will be determined by the pepsin digestibility method (Mertz *et al.,* 1984). Pepsin solution was prepared by dissolving 1.5mg/mL of pepsin in 0.035M HCl with pH 2.0.200 mg powdered sample was suspended in 35mL pepsin solution and incubated at 37°C with gentle shaking for 2h. This solution was centrifuged at 12,000g for 15min at 40°C and the residue was suspended in 10mL 0.035M HCl and centrifuged again. Residue was collected and dried overnight at 40°C.

Total nitrogen of the dried residue was determined by micro-Kjeldahl method. A blank solution was run with each assay without addition of enzyme solution.

Statistical analysis

All the results were analyzed statistically for its evaluation analysis of variance (ANOVA) technique by using SPSS 17. The means differences were evaluated by using the Least Significant Design (Steel *et al.,* 1997).

Results and discussion

The objective of this research was to determine the effects of minerals, fennel and carrots juice on the physico-chemical, sensory properties and shelf stability of food bars.

Table 1. Formulation of food bars.

Ingredients	Quantity (g)
Corn flour	30
Butter	40
Almonds	30
Sugar	140
Liquid glucose	40
Milk powder	50
Carrot juice	50 ml
Salt	2.0
Fennel Seeds	As per Table 2
Minerals (Spinach Ash)	As per Table 2

Table 2. Treatment plan of food bars.

Treatments	Fennel Seeds (g)	Spinach Ash (%)
FB_0	-	-
FB_1	10	1
FB_2	20	2
FB_3	10	2
FB_4	20	1

Physico-chemical analysis of food bars

Texture analysis of food bars

The values of hardness were found from 149.24±14.11 to 341.33±22.18 g (Table 3). This indicates that FB_0 had less hardness (149.24±14.11 g) and it gradually increased towards FB_2 (341.33±22.18 g). Hence, addition of fennel seed powder in food bars increases hardness.

On the other hand, factorability values ranged from 64.83±0.83 to 74.63±1.35 mm having the lowest value for FB_0 and the highest value in FB_2 (Table 4).

Table 3. Mean values for hardness (g) of food bars during storage.

Treatments	Days				Means
	0	30	60	90	
FB_0	133.03±3.45	142.53±1.80	157.05±3.42	164.36±3.20	149.24±14.11 E
FB_1	171.84±2.99	179.79±1.60	190.42±1.52	197.63±1.46	184.92±11.39 D
FB_2	317.90±3.35	330.62±2.72	347.69±2.28	369.10±2.44	341.33±22.18 A
FB_3	208.14±3.25	217.84±1.24	232.48±3.85	245.78±2.66	226.06±16.52 C
FB_4	256.23±3.66	270.94±3.51	288.41±5.21	302.60±4.58	279.54±20.23 B
Means	217.43±72.26 D	228.34±74.33 C	243.21±76.30 B	255.89±81.96 A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds

Table 4. Means for factorability values (mm) of food bars.

Treatments	Days				Means
	0	30	60	90	
FB_0	65.67±1.19	65.43±0.55	64.20±1.16	64.03±1.28	64.83±0.83 E
FB_1	69.29±0.92	67.52±0.98	67.23±1.03	65.79±0.88	67.46±1.44 D
FB_2	75.62±1.16	75.26±1.07	74.98±1.16	72.65±1.08	74.63±1.35 A
FB_3	72.24±1.28	69.38±1.30	69.12±1.22	67.61±1.26	69.59±1.93 C
FB_4	74.07±1.10	72.38±1.11	72.06±1.08	69.55±1.10	72.01±1.87 B
Means	71.38±3.07 A	69.99±3.90 B	69.52±4.18 B	67.93±3.34 C	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

There was a significant effect of storage on texture of food bar. Hardness of food bars increased during storage of 90 days.

The hardness value was 217.43±72.26 g at start of study and increased upto 255.89±81.96 g after 90 days. Same trend was observed for factorability. Both had inverse relationship during storage.

In this study, the main objective was to evaluate the effect of addition of fennel seeds saturated with carrot juice and spinach ash on the physico-chemical and sensory properties of food bars.

In the present investigation, it was found that with the addition of fennel seeds, physical properties of food bars improved in terms of texture.

The data regarding texture is in line with the findings of Chen (2008) who observed that hardness increased from 392 to 866 at 0 and 60 days respectively during storage in probiotic-fortified soy energy bar.

Table 5. Mean values for water activity of food bars during storage.

Treatments	Days				Means
	0	30	60	90	
FB_0	0.565±0.002	0.558±0.003	0.551±0.004	0.546±0.546	0.555±0.008 C
FB_1	0.570±0.005	0.567±0.001	0.558±0.003	0.551±0.004	0.562±0.009 AB
FB_2	0.577±0.002	0.568±0.001	0.556±0.003	0.552±0.003	0.563±0.011 A
FB_3	0.572±0.004	0.564±0.003	0.556±0.001	0.547±0.001	0.560±0.011 B
FB_4	0.575±0.003	0.565±0.002	0.562±0.002	0.555±0.003	0.564±0.008 A
Means	0.572±0.005 A	0.565±0.004 B	0.557±0.004 C	0.550±0.004 D	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Table 6. Mean values for moisture content (%) in food bars during storage.

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	5.27±0.02k-m	5.12±0.03lm	4.96±0.05mn	4.69±0.01n	5.01±0.25D
FB_1	5.81±0.04g-i	5.60±0.05h-k	5.43±0.01j-l	5.17±0.01lm	5.50±0.27C
FB_2	6.68±0.04d	6.41±0.01de	6.21±0.03ef	6.01±0.02fg	6.33±0.28B
FB_3	5.94±0.03f-h	5.70±0.02g-j	5.44±0.04i-l	5.22±0.07k-m	5.58±0.31C
FB_4	7.88±0.05a	7.80±0.03ab	7.46±0.01bc	7.12±0.06c	7.56±0.35A
Mean	6.32±1.01a	6.12±1.04b	5.90±0.98c	5.64±0.95d	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Water activity (aw) of food bars

The mean values of water activity in food barsranged from 0.555±0.008 to 0.564±0.008. The lowest water activity (0.555±0.008) was observed in FB_0 and the highest (0.564±0.008) in FB_4. There was a gradual increase in water activity with increasing concentrations of fennel seed powder and spinach ash in treatments. The water activity during storage period decreased from 0.572±0.005 to 0.550±0.004 at 0 and 90 days respectively (Table 5).

Table 7. Mean values for protein content (%) during storage.

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	3.88±0.04	3.89±0.08	3.85±0.03	3.89±0.01	3.88±0.02A
FB_1	4.07±0.07	4.08±0.03	4.09±0.01	4.10±0.01	4.09±0.01A
FB_2	4.19±0.02	4.18±0.01	4.13±0.04	4.18±0.06	4.17±0.01A
FB_3	4.10±0.04	4.09±0.06	4.11±0.02	4.08±0.03	4.09±0.01A
FB_4	4.24±0.01	4.24±0.05	4.25±0.05	4.25±0.02	4.25±0.01A
Means	4.10±0.14A	4.10±0.13A	4.09±0.29A	4.10±0.14A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

The decrease in water activity might be due to the decrease in moisture content during storage.These findings of water activity in the present investigation are in line with the findings of Estivez *et al.* (1995) who found that water activity decreased from 0.71 to 0.52 at 0 and 60 days respectively during storage in cereal and nut bars. Similar findings were also reported by Yousif *et al.* (1990) who noted that water activity was recorded 0.75 at 0 day.

This water activity reduces from 0.75 to 0.64 after storage of 6 months at ambient temperature. In the present investigations, results revealed that water activity increased within treatments with addition of fennel seeds and ash content. Water holding capacity of food bars improved with the addition of fennel seeds resulting in higher water activity.

Proximate analyses of food bars

The moisture content of food bars range from 5.01±0.25 (FB_0) to 7.56±0.35% (FB_4).During storage, moisture content decreased from 6.32±1.01 to 5.64±0.95% in 90 days (Table 6). The results of moisture content were aligned with the results of Rehman *et al.* (2012) who observed that moisture contents increased with the addition of dried apricot paste in bars.

The minimum moisture in control treatment was possibly because of change in water holding capacity of variables used (Zubay, 1999). Moisture contents are affected greatly by the change in sugar (carbohydrates) contents (Sun-Waterhouse *et al.,* 2010). The popularity of cereal foods products is highly influenced by textural properties and most important property is moisture contents (Liu *et al.,* 2000; Gates *et al.,* 2008). Plasticizing/anti-plasticizing effects and brittle material can result from elevated water contents (Lewicki, 2004) which ultimately leads to crispness loss.

Table 8. Mean values for fiber content (%) in food bars during storage**.**

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	3.89±0.02c	3.87±0.06c	3.87±0.02c	3.84±0.01c	3.87±0.02 C
FB_1	5.02±0.01b	5.01±0.02b	5.02±0.07b	5.02±0.04b	5.02±0.01 B
FB_2	5.49±0.03a	5.48±0.04a	5.49±0.03a	5.50±0.03a	5.49±0.01 A
FB_3	5.04±0.06b	5.03±0.03b	5.02±0.04b	5.02±0.1b	5.03±0.01 B
FB_4	5.51±0.02a	5.50±0.01a	5.41±0.05a	5.44±0.03a	5.47±0.05 A
Means	4.99±0.66A	4.98±0.66A	4.97±0.65A	4.97±0.67A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Protein content of food bars

Protein content of food bars were 3.88±0.02 (FB_0) to 4.25±0.01% (FB_2) inall treatments. During storage, non-significant change in protein content was noticed (Table 7).

The supplementation of protein infood bars by use of a plant or animal protein source or combination of both can increase the protein contents to significant level (Nadeem *et al.,* 2012).The protein content are not affected significantly during storage but are affected during processing mainly because of Strecker degradation (degradation of amino acid) and Millard browning (nonenzymatic chemical reaction) (Onwuka and Abasiekong, 2006).

In another study it was reported that total protein contents of food bars increased with the addition of apple puree because protein–polyphenol complexes were formed in the bars, saving protein from heat induced breakdown which can occur during baking (Sun-Waterhouse *et al.,* 2010).

Table 9. Mean values for fat content (%) in food bars during storage.

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	9.15±0.03hi	9.11±0.02hi	9.08±0.03i	9.17±0.02h	9.12±0.04C
FB_1	9.34±0.04def	9.32±0.06efg	9.31±0.02fg	9.39±0.01d	9.34±0.04B
FB_2	9.59±0.01a	9.56±0.04ab	9.27±0.03g	9.50±0.01bc	9.48±0.04A
FB_3	9.37±0.05de	9.34±0.02def	9.30±0.01fg	9.39±0.06d	9.35±0.04B
FB_4	9.53±0.01abc	9.47±0.03c	9.50±0.05bc	9.49±0.03c	9.50±0.03A
Means	9.40±0.17A	9.36±0.17A	9.38±0.15A	9.39±0.13A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Fiber content

Fiber content (5.49±0.01%) was the highest in FB_2 (Table 8). The mean values of fiber contents were not changed significantly during 90 days.Among the ingredients used in bars, fennel and corn flour are rich source of dietary fibres (DF). Thehighest amount of DF was found in apple-DF snack bars (Sun-Waterhouse *et al.,* 2010). The DF in fruit bars are some soluble and mostly insoluble fibres (Sun-Waterhouse *et al.,* 2008). Water holding capacity makes the difference between soluble and insoluble dietary fibres for food formulations.

Table 10. Mean values for ash content (%) in food bars during storage.

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	0.21±0.01f	0.20±0.02f	0.20±0.05f	0.21±0.01f	0.21±0.01e
FB_1	0.98±0.02d	0.88±0.05e	0.96±0.07de	0.98±0.03d	0.94±0.05d
FB_2	1.51±0.04a	1.50±0.01a	1.50±0.02a	1.49±0.05a	1.50±0.01a
FB_3	1.24±0.05b	1.24±0.04b	1.17±0.04bc	1.23±0.03b	1.22±0.03b
FB_4	1.10±0.07c	1.09±0.02c	1.10±0.02c	1.10±0.04c	1.10±0.01c
Means	1.01±0.49A	0.98±0.49A	0.99±0.48A	1.00±0.48A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Fat content of food bar

Fat content of food bar samples were 9.12±0.04, 9.34±0.04, 9.48±0.04, 9.35±0.04 and 9.50±0.03% for FB_0, FB_1, FB_2, FB_3 and FB_4 respectively (Table 9). The fat contents in food bars changed non-significantly during storage. The fat contents increased with the increasing quantity of fennel seed powder. Among the ingredients used in the preparation of bars, butter and almonds are the richest source of fat and are an energy-dense food. Studies have revealed that incidence of cardiovascular diseases is inversely proportional to the consumption of almonds (Albert *et al.,* 2002).

Minimum ash content

The minimum ash content (0.21±0.01%) was observed in FB_0 while the highest ash content (1.50±0.01%) was observed in FB_2 (Table 10). During storage of 90 days the ash content was maintained. Presence of plant extract (apple puree) increased the ash contents in snacks bars (Sun-Waterhouse *et al.,* 2010). The ash contents (minerals) in the bars were mainly due to the presence of the fennel seed saturated with carrot juice used and spinach ash. Carrots contain appreciable quantity of minerals, as carrot pomace contains 5.5±0.10% ash contents on dry basis (Sharma *et al.,* 2012).

Table 11. Mean values for NFE content (%) during storage.

Treatments	Storage (days)				Mean
	0	30	60	90	
FB_0	77.60±0.03a	77.81±0.05a	78.03±0.13a	78.21±0.05a	77.91±0.26A
FB_1	74.78±0.012ab	75.11±0.03a	75.20±0.01a	75.35±0.06a	75.11±0.24AB
FB_2	72.55±0.09ab	72.86±0.07ab	66.09±0.04b	73.32±0.02ab	71.20±0.42C
FB_3	74.30±0.03ab	74.61±0.02ab	74.96±0.05a	75.06±0.07a	74.73±0.35AB
FB_4	71.73±0.04ab	71.89±0.01ab	72.27±0.02ab	72.60±0.04ab	72.12±0.39BC
Means	74.19±2.28A	74.46±2.28A	73.31±4.52A	74.91±2.18A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

NFE contents in food bars

The NFE contents in food bars were 71.20±0.42 to 77.91±0.26% (Table 11). The lowest NFE value was observed for FB_2 while the highest value was observed for FB_0. During storage, the mean values remain almost constant.

Calorific value of food bars

Gross energy values differ highly significantly among treatments (Table 12) and range from 372.93±1.22 to 389.82±0.94 Kcal/100g. These food bars were developed using appreciable amount of nutrients especially carbohydrates, protein, fat and fiber. These food bars provide nutrients as well as energy. These bars are suitable for all age groups particularly children and sportsman. The results regarding the change in calorific value is in close agreement with the findings of Rehman *et al.* (2012), who observed that calorific value varied significantly among treatment of apricot-date bars.

In-vitroprotein digestibility (IVPD) of food bars

In-vitro protein digestibility values in food bars range from 85.78±1.33 to 87.41±0.11% (Table 13). Results indicated that the maximum *in-vitro* protein digestibility values are recorded in FB_2 (87.41±0.11%) and FB_4 (87.30±0.82%) while, the minimum value (85.78±1.33%) was observed in control bar (FB_0). Addition of fennel seed saturated with carrot juice increased the *in-vitro* protein digestibility. The effect of storage on the in-vitro protein digestibility was non-significant ($p \geq 0.05$).

Table 12. Means for calorific value (Kcal/100g) of food bars during storage.

Treatments	Days				Means
	0	30	60	90	
FB_0	388.83±0.07	389.33±0.17	389.76±0.24	391.35±0.21	389.82±0.94 A
FB_1	380.76±0.04	381.87±0.40	382.09±0.27	383.47±0.22	382.05±0.96 B
FB_2	375.09±0.55	376.00±0.74	376.98±3.16	377.16±0.47	376.31±0.83 D
FB_3	379.41±0.05	380.17±0.05	381.24±0.21	382.28±0.11	380.77±1.09 C
FB_4	371.75±0.22	371.80±0.10	373.55±1.93	374.62±0.25	372.93±1.22 E
Means	379.17±6.47 D	379.83±6.59 C	380.72±6.11 B	381.78±6.47 A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

The *in-vitro* protein digestibility of fruit bars is comparable with the in-vitro digestibility of date bars which were fortified with soy protein isolates and skim milk powder (Sawaya *et al.,* 1983). The in-vitro digestibility of these food bars was 85.78 to 87.41% which are in line with the in-vitro protein digestibility of fruit bars. The change of IVPD during storage for various treatments is in close agreement with the findings of Pinto *et al.* (2005) who reported non-significant effect of storage on IVPD in all four treatments of soy protein isolates and defatted soy flours during 6 month storage at 42°C.

In-vitrostarch digestibility (IVSD) of food bars

The *in-vitro* starch digestibility varied from 330.50±0.24 to 367.39±0.86 (mg maltose/g) (Table 14). The results revealed that addition of fennel seeds in food bars improves starch digestibility. Rehman *et al.* (2012) studied effect of addition of dried apricot powder on physico-chemical characteristics of bars. They reported increase in in-vitro starch digestibility in bars with increase in dried apricot. Banana fruit bars were developed in which banana flour was used and it was observed that In-vitro starch digestibility was improved with addition of banana flour in fruit bars (Utrilla-Coello *et al.*, 2010).

Table 13. Means for in-vitro protein digestibility (%) of food bars during storage.

Treatments	Days		Means
	0	90	
FB_0	85.70±1.07	85.85±1.10	85.78±1.33 B
FB_1	87.47±0.79	85.98±0.78	86.73±1.06 AB
FB_2	87.25±0.84	87.56±0.95	87.41±0.11 A
FB_3	87.37±0.12	85.49±0.91	86.43±0.22 AB
FB_4	86.72±0.52	87.88±0.56	87.30±0.82 A
Means	86.91±0.73 A	86.55±1.09 A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Table 14. *In-vitro* starch digestibility (mg/100g maltose equivalent) of food bars during storage.

Treatments	Days		Means
	0	90	
FB_0	330.67±1.53	330.33±1.69	330.50±0.24 E
FB_1	338.30±4.18	338.67±2.08	338.48±0.26 D
FB_2	359.67±3.21	360.67±1.53	360.17±0.39 B
FB_3	348.55±3.34	348.00±2.65	348.28±0.71 C
FB_4	366.78±1.57	368.00±2.00	367.39±0.86 A
Means	348.79±14.84 A	349.13±15.44 A	

Different alphabets with means represent significant trend.

FB_0 = Bars without ash and fennel seeds; FB_1= Bars with 1% ash and 10g fennel seeds; FB_2= Bars with 2% ash and 20g fennel seeds; FB_3= Bars with 2% ash and 10g fennel seeds; FB_4= Bars with 1% ash and 20g fennel seeds.

Minerals content of food bars

Mineral analysis of food bar samples indicated that sodium (Na) was found in the range of 3.92±0.24 to 112.92±0.37mg/100g, potassium (K) 108.17±1.37 to 419.12±1.40mg/100g, calcium (Ca) 28.48±1.02 to 160.76±1.31mg/100g, magnesium (Mg) 39.33±1.30 to 49.56±1.38mg/100g, iron (Fe) 0.71±0.01 to 30.51±0.04mg/100g, copper (Cu) 0.12±0.01 to 4.39±0.02mg/100g and zinc (Zn) 0.57±0.01 to 1.33±0.02mg/100g (dry weight basis) in food bar samples (Table 15). Minerals content increase significantly with the addition of fennel seeds and spinach ash in food bars, while the minimum minerals content was observed in control food bar (FB_0) having no added mineral source.

In this study, the main objective was to evaluate the combined effect of addition of fennel seeds and spinach ash instead of in-organic source of minerals on the nutritional profile and minerals content of food bars. Fennel seeds and spinach ash have been proved as natural source for minerals supplementation in the development of food bars as it improved nutritional benefits. Spinachis locally available cheap and good source of minerals.

Table 15. Mean values for mineral content in food bars (mg/100g).*

Treatments	Na	K	Ca	Mg	Fe	Cu	Zn
FB_0	3.92 ± 0.24e	108.17 ± 1.37c	28.48 ± 1.02e	39.33 ± 1.30c	0.71 ± 0.01c	0.12 ± 0.01c	0.57 ± 0.01d
FB_1	58.42 ± 0.80d	263.64 ± 1.04b	94.62 ± 0.94d	44.45 ± 0.98b	15.2 ± 0.01b	2.20 ± 0.01b	0.94 ± 0.01c
FB_2	112.92 ± 0.37a	419.12 ± 1.40a	160.76± 1.31a	49.56 ± 1.38a	30.51 ± 0.04a	4.39 ± 0.02a	1.33 ± 0.02a
FB_3	87.83 ± 0.80b	264.46 ± 0.93b	116.00 ± 1.03c	44.46 ± 0.94b	30.40 ± 0.02a	4.38 ± 0.02a	1.17 ± 0.01b
FB_4	83.51 ± 0.58c	418.30 ± 0.83a	139.38 ± 0.86b	49.55 ± 0.83a	15.40 ± 0.01b	2.24 ± 0.01b	1.11 ± 0.02b

Means with different letters in each column differ highly significantly p<0.01.

*= dry weight basis.

The results are supported to the findings of Passos *et al.* (2013) in commercial cookies for proximate and mineral content. Niaba *et al.* (2013) found that mineral content increased in cookies supplemented with Macrotermes subhyalinus flour.

Conclusion

Fennels saturated with carrot juice would contribute effectively in providing good nutrition in the form of readily digestible carbohydrates, protein, vitamins and minerals in appreciable amounts. During storage, all treatments of food bars were recorded as acceptable for for 90 days but FB_2 was found the best among different types of bars. So, food bars development and characterization by different parameters represent that these are highly nourishing that could be used at any time which fulfills the nutritional requirements of all age groups.

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