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Effect of Beetroot Powder Incorporation on the Textural, Sensory and Nutritional Quality of Legume and Oil Seeds Based Snack Bar

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ABSTRACT

Background: Beetroot is a good source of carbohydrates and minerals with the highest antioxidant activity and phenol content among all the roots and tubers. However, even after immense nutritional potential its application in food formulations is very limited. Therefore, the present study aims at formulation of beetroot powder (BRP) incorporated snack bars, their textural, sensory evaluation and analysis of nutritional composition of most acceptable snack bar.

Methods: Fifteen snack bars were prepared using different proportions of BRP (0, 5, 10, 15, 20%) with varying levels of honey, bengal gram and flax seeds. Formulated snack bars were subjected to textural and sensory evaluation to determine the most acceptable snack bar followed by its nutritional analysis.

Result: With increase in the level of BRP, hardness value decreased among snack bars significantly ($p<0.05$); while springiness, gumminess and chewiness increased initially up to 10% of BRP incorporation. Sensory quality of snack bars significantly ($p<0.05$) declined with increase in the level of BRP. Based on the textural and sensory properties, control bar A_3 (0 g BRP) and D_3 bar (15 g BRP) were found most acceptable. Nutrient analysis of both the snack bars revealed that D_3 snack bar had significantly ($p<0.05$) higher amount of ash, carbohydrate, total phenol, flavonoids and total antioxidant activity than A_3 bar.

Key words: Beetroot powder, Nutritional composition, Phenol content, Sensory acceptability, Snack bars.

INTRODUCTION

Since past decade, World Health Organization recommends formulation of innovative food products (WHO, 2004) while keeping the customers nutritional requirements in mind. Nowadays, consumers are demanding such processed snack foods which are less perishable, tastier and convenient and above all contribute to health benefits. Food manufacturers are also coming forward with wide variety of snacks specifically prepared with natural products to satisfy wide consumer spectra.

Snack bars are gaining importance worldwide since these are available with numerous nutritional claims of being rich in fibre, omega-3, protein, antioxidants *etc*. Mostly these snack bars are formulated using different food groups alone or in combination including fruits, millets, cereals, oil seeds and natural sweeteners. However, the use of synthetic colorants, flavors and antioxidants to enhance the sensory appeal and shelf life of these bars is of prime concern among health conscious consumers due to its adverse health effects (Shahidi and Ambigaipalan, 2015). Therefore, use of natural food ingredients without addition of synthetic chemicals should be the prime focus of manufacturers in order to maximize the health benefits of these nutritious bars.

Beetroot (*Beta vulgaris*) contains fair amount of protein and fat but considered a good source of dietary fibre, carbohydrates, folate, minerals *viz*. potassium, phosphorus, magnesium and bioactive compounds like: flavonoids and carotenoids (Georgiev *et al*., 2010; Longvah *et al*., 2017). It is also elucidated to have highest phenols and antioxidant activity among all the roots and tubers (Sreeramulu and Raghunath, 2010). The major phenolic compound present in beetroot is betalains, which imparts significant red color and also used as a natural colorant in variety of food systems. It has also been found to possess high antioxidant activity (Georgiev *et al*., 2010) which is associated with numerous health benefits including inhibition of lipid peroxidation, anti-inflammatory and chemo-preventive properties (Reddy *et al*., 2005).

Despite the superior nutritional quality, beetroot consumption is very limited owing to its limited availability due to its high moisture content, sustained metabolism and microbial attack, leading to damage during harvesting and storage (Agbor-Egbe and Rickard, 1991). Hence, to curtail

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its spoilage problem, simple processing method like drying can be applied. Dried beetroots can further be converted into chips or powder for the formulation of nutritious snack foods.

Therefore, the present study aims at 1) formulation of beetroot powder (BRP) incorporated legume and oil seeds based snack bars, 2) analysis of textural and sensory qualities of formulated snack bars and 3) nutrient evaluation of most acceptable snack bars.

MATERIALS AND METHODS

Procurement of raw ingredients

The study was conducted in year 2017 (January-June) in Foods and Nutrition Department, College of Home Science, G.B.P.U.A. and T., Pantnagar, Uttarakhand, India. For the study, fresh beetroots were procured from Pantnagar haat. Other raw materials *viz*; flax seeds, roasted bengal gram, honey, sesame seeds, roasted peanuts and dry coconut were purchased from local Pantnagar market.

Preparation of BRP and other ingredients

Fresh beetroots were peeled, washed properly and cut into thin, round slices (<4 mm) followed by its drying at 60°C temperature for 6 hours in hot air oven. Dried beetroot slices were ground into fine powder using electric grinder. Other ingredients *viz*; dry coconut was grated into small chips, roasted peanuts were cut into small pieces after skin removal, flax seeds and sesame seeds were roasted for 2 minutes, separately and allowed to cool. Roasted bengal gram and roasted flax seeds were ground into coarse powder using electric grinder.

Table 1: Ingredients used in the formulation of beetroot powder (BRP) incorporated snack bars.

Nutritious snack bars	BRP incorporation (g)	Honey (g)	Flax seed (g)	Bengal gram (g)
A_1	0	32	26	26
A_2		34	25	25
A_3		36	24	24
B_1	5	32	23.5	23.5
B_2		34	22.5	22.5
B_3		36	21.5	21.5
C_1	10	32	21	21
C_2		34	20	20
C_3		36	19	19
D_1	15	32	18.5	18.5
D_2		34	17.5	17.5
D_3		36	16.5	16.5
E_1	20	32	16	16
E_2		34	15	15
E_3		36	14	14

* Amount of other ingredients: Sesame seeds 8 g, coconut chips 5 g, peanuts 3 g in 100 g of each snack bar.

Preparation of snack bars

Table 1 represents various ingredients used in different proportions for the formulation of fifteen snack bars. For the preparation of BRP incorporated snack bars (B_1-E_3), BRP, bengal gram powder, flax seeds powder and honey in different proportions were mixed with roasted sesame seeds, roasted peanuts and coconut chips. Control snack bars (A_1-A_3) had same ingredients except BRP. Thereafter, well mixed mixture for each combination was placed and spread uniformly using rolling pin on aluminum tray and snack bars weighing 50 g were cut out with the help of moulds measuring 9×3×1.5 cm^3 size. Each individual snack bar was packed properly in High Density Polyethylene bags for further analysis.

Texture analysis

Texture analysis was performed at room temperature using HDTA plus texture analyzer in strain mode with a cylindrical probe using three pieces (2×2×1.5 cm^3) of each sample which were compressed twice to 50% of original height. Pre-test, test and post-test speeds were 1, 1 and 5 mm/s respectively. From the resulting curves hardness, cohesiveness, springiness, gumminess and chewiness were determined.

Sensory evaluation

All the snack bars were evaluated for their sensory quality by a semi-trained panel of 15 members from the Department of Foods and Nutrition, G.B.P.U.A.T., Pantnagar. Nine point Hedonic scale (Amerine *et al*., 1965) was used to find out the most acceptable snack bar based on various sensory parameters. Most acceptable control bar and BRP incorporated snack bar were further subjected to nutrient analysis and shelf life study.

Nutrient composition of control bar and BRP snack bar

For analyzing the nutrient composition snack bars were crushed, dried in hot air oven at 60°C for 120 minutes and then ground into fine powder.

Proximate composition and mineral analysis

Moisture, total ash, crude protein (using the factor 6.5 × N), crude fat and crude fiber content were analyzed as per the standard methods of AOAC (AOAC, 2000). The carbohydrate content and physiological energy value were calculated using the following equations.

% Carbohydrate =
100 - [moisture (%) + ash (%) + crude fat (%) + crude protein (%) + crude fiber (%)]

Physiological energy value (Kcal/100 g) =
[Carbohydrate (%) × 4 + [Protein (%) × 4 + [Fat (%) × 9]

The minerals like calcium and iron were estimated using atomic absorption spectrophotometer method (Raghuramulu *et al*., 2003).

Total phenolic content, flavonoids, total antioxidant activity and folic acid

Total phenolic content of samples was determined as per Folin-Ciocalteu's method (Singleton *et al*., 1999). Total antioxidant activity was estimated by DPPH (2.2-Diphenyl-1-picrylhydrazyl) radical scavenging activity (Brand-Williams *et al.,* 1995). Total flavonoid content was measured according to colorimetric assay (Zhishen *et al*., 1999) and folic acid content was determined as per method illustrated by Ranganna (1986).

Statistical analysis

Statistical analysis was performed using WASP version 1, developed by ICAR-CCARI, Goa, India. All the experiments were conducted in triplicate except texture analysis and sensory evaluation (fifteen observations). Data pertaining to textural and sensory properties were analyzed using one way ANOVA. Two sample t-test was used to analyze the data of nutrient composition.

RESULTS AND DISCUSSION

Texture analysis of formulated snack bars

For the evaluation of textural qualities, texture profile analysis (TPA) is the most commonly used standard test which quantifies various textural parameters in just one experiment. The textural properties of all the snack bars (A_1-E_3) have been presented in Table 2. The hardness values for all the snack bars were significantly different ($p<0.05$) which suggests that the incorporation of BRP altered the textural properties of all snack bars. On increasing the level of BRP from 5%-20%, all the BRP incorporated snack bars (B_1-E_3) showed decline in the hardness values. Similarly, gradual increase in the amount of honey (32% to 36%) also decreased the hardness values. Higher amount of honey may have resulted in better binding of ingredients at 36% than 32% and 34% which in turn may have decreased hardness properties. Hardness values for all the snack bars ranged from 40.25 N to 129.20 N, which were remarkably lower than the hardness values (99.606 N to 157.956 N) for the cereal bar containing pineapple peel flour (Aparecida *et al*. 2016) suggesting that snack bars formulated in the present study are softer. Regarding springiness property, gluten free nature of all the ingredients used in this study resulted in very low springiness for snack bars ranging from 0.12 mm to 0.27 mm.

With respect to cohesiveness, it was observed that cohesiveness increased with increase in amount of honey at same level of BRP which indicates that higher moisture content due to addition of higher amount of honey and BRP, lead to better cohesiveness. An increasing trend was also observed in case of gumminess and chewiness but only up to 10% incorporation level of BRP followed by a gradual decrease in the values with 15% and 20% of BRP, indicating that the force needed to disintegrate the snack bars to a steady state of swallowing decreased at 15% and 20% BRP incorporation level. Results observed in the present study are in agreement with those reported by Bchir *et al.* (2018) and Mridula *et al*. (2013) for cereal bar and flax seed enriched bar, respectively.

Sensory evaluation of formulated snack bars

Formulated snack bars (A_1-E_3) were evaluated for various sensory parameters *viz*; taste, after taste, color and appearance, texture and overall acceptability using nine- point Hedonic scale (Table 3). In case of BRP incorporated snack bars (B_1-E_3) sensory quality declined with increase in the level of BRP. Mean sensory scores for taste and after taste decreased

Table 2: Texture profile analysis of control snack bars and BRP incorporated snack bars.

Nutritious snack bars	BRP incorporation (g)	Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N/mm)
A_1	0	80.69 ± 0.49^{f}	0.09 ± 0.01^{d}	0.12 ± 0.00^{f}	7.26 ± 0.17^{k}	0.86 ± 0.04^{k}
A_2		70.24 ± 0.88^{i}	0.12 ± 0.02^{bcd}	0.12 ± 0.04^{f}	8.42 ± 0.11^{i}	1.01 ± 0.03^{j}
A_3		40.25 ± 0.62^{l}	0.20 ± 0.07^{a}	0.15 ± 0.01^{ef}	8.04 ± 0.13^{j}	1.2 ± 0.08^{i}
B_1	5	129.20 ± 0.62^{a}	0.10 ± 0.01^{bcd}	0.16 ± 0.02^{def}	12.91 ± 0.17^{a}	2.06 ± 0.08^{d}
B_2		111.93 ± 0.55^{c}	0.10 ± 0.00^{cd}	0.18 ± 0.01^{cde}	11.18 ± 0.10^{d}	2.01 ± 0.03^{d}
B_3		55.33 ± 0.72^{k}	0.19 ± 0.00^{a}	0.18 ± 0.02^{cde}	10.51 ± 0.12^{ef}	1.88 ± 0.08^{e}
C_1	10	122.67 ± 0.41^{b}	0.10 ± 0.00^{cd}	0.22 ± 0.04^{abc}	12.26 ± 0.16^{b}	2.69 ± 0.12^{a}
C_2		96.02 ± 0.41^{d}	0.12 ± 0.00^{bcd}	0.21 ± 0.00^{abcd}	11.52 ± 0.13^{c}	2.41 ± 0.04^{bc}
C_3		72.67 ± 0.91^{h}	0.12 ± 0.01^{bcd}	0.27 ± 0.02^{a}	8.71 ± 0.15^{h}	2.34 ± 0.07^{c}
D_1	15	95.38 ± 0.36^{d}	0.11 ± 0.00^{bcd}	0.24 ± 0.05^{ab}	10.48 ± 0.10^{ef}	2.51 ± 0.07^{b}
D_2		86.02 ± 0.65^{f}	0.12 ± 0.01^{bcd}	0.19 ± 0.04^{bcde}	10.32 ± 0.10^{f}	1.95 ± 0.05^{de}
D_3		63.73 ± 0.47^{j}	0.14 ± 0.02^{b}	0.15 ± 0.03^{ef}	8.92 ± 0.14^{h}	1.33 ± 0.07^{h}
E_1	20	89.01 ± 0.34^{e}	0.12 ± 0.00^{bcd}	0.16 ± 0.01^{def}	10.67 ± 0.18^{e}	1.70 ± 0.04^{f}
E_2		72.23 ± 0.49^{h}	0.13 ± 0.00^{bc}	0.16 ± 0.04^{def}	9.38 ± 0.13^{g}	1.49 ± 0.04^{g}
E_3		64.41 ± 0.19^{j}	0.13 ± 0.01^{bc}	0.14 ± 0.01^{ef}	8.37 ± 0.14^{i}	1.16 ± 0.04^{i}

* All values are mean of triplicate observations±standard deviation.

* Means having different superscripts differ significantly in each column ($p<0.05$).

significantly ($p<0.05$) which may be due to geosmin, an endogenously produced volatile compound in beetroot, which imparts undesirable earthy taste (Bach *et al*., 2015). Bars incorporated with 20% of BRP (E_1-E_3) received lowest scores for all the sensory parameters due to unpleasant taste, appearance and after-taste. Increased level of BRP also resulted in darker earthy red color in snack bars which could be attributed to pigments betalains and betaxanthins in beetroot (Bach *et al*., 2015). Among control bars (A_1-A_3 with 0% BRP), A_3 bar received highest scores for all the sensory parameters including overall acceptability (7.57). However, in case of BRP incorporated bars, all the bars with 5%-15% of BRP (B_1-D_3) were highly acceptable and showed no significant difference with control bar A_3 (0% BRP) in terms of overall acceptability. Therefore, D_3 snack bar with 15% of BRP and A_3 control bar were selected for nutrient analysis and shelf life study. Singh *et al*. (2016) in their study reported 10% BRP level to be the most acceptable for BRP incorporated corn extrudates. However, in another study noodles prepared with 30% of beetroot pulp were found most acceptable (Chhikara *et al*., 2019).

Proximate composition and mineral analysis of A_3 control bar and D_3 snack bar

Beet root is a fair source of protein (1.95%), fat (0.14%), total dietary fibre (3.31%), ash content (1.46%), energy

Table 3: Sensory evaluation of control snack bars and BRP incorporated snack bars.

Code	BRP incorporation (g)	Taste	Color and appearance	Texture	After taste	Overall acceptability
A_1	0	7.06 ± 0.16^{d}	7.36 ± 0.39^{fg}	7.50 ± 0.50^{abc}	7.24 ± 0.36^{bc}	7.30 ± 0.78^{c}
A_2		7.56 ± 0.53^{bc}	7.39 ± 0.50^{efg}	7.42 ± 0.68^{abcd}	7.50 ± 0.59^{ab}	7.48 ± 0.70^{abc}
A_3		7.60 ± 0.47^{bc}	7.39 ± 0.40^{efg}	7.42 ± 0.51^{abcd}	7.64 ± 0.65^{a}	7.57 ± 0.67^{abc}
B_1	5	7.66 ± 0.64^{abc}	8.0 ± 0.50^{a}	7.85 ± 0.49^{a}	7.60 ± 0.53^{a}	7.86 ± 0.54^{ab}
B_2		7.97 ± 0.52^{a}	8.02 ± 0.34^{a}	7.80 ± 0.67^{ab}	7.78 ± 0.66^{a}	7.90 ± 0.66^{a}
B_3		7.82 ± 0.47^{ab}	7.92 ± 0.41^{ab}	7.50 ± 0.63^{abc}	7.74 ± 0.53^{a}	7.60 ± 0.71^{abc}
C_1	10	7.45 ± 0.33^{c}	7.76 ± 0.45^{abcd}	7.37 ± 0.69^{bcd}	7.17 ± 0.36^{bcd}	7.40 ± 0.43^{bc}
C_2		7.64 ± 0.45^{bc}	7.71 ± 0.51^{abcde}	7.15 ± 0.73^{cd}	7.10 ± 0.60^{cd}	7.42 ± 0.73^{bc}
C_3		7.70 ± 0.49^{abc}	7.85 ± 0.46^{abc}	7.32 ± 0.75^{cd}	6.86 ± 0.48^{de}	7.46 ± 0.54^{abc}
D_1	15	7.56 ± 0.37^{bc}	7.57 ± 0.56^{cdef}	7.25 ± 0.68^{cd}	6.70 ± 0.49^{ef}	7.28 ± 0.65^{c}
D_2		7.64 ± 0.47^{bc}	7.64 ± 0.38^{bcdef}	7.10 ± 0.50^{cde}	6.47 ± 0.35^{fg}	7.53 ± 0.63^{abc}
D_3		7.65 ± 0.37^{abc}	7.56 ± 0.44^{cdef}	7.25 ± 0.49^{cd}	6.16 ± 0.48^{g}	7.50 ± 0.59^{abc}
E_1	20	6.26 ± 0.31^{e}	7.41 ± 0.51^{defg}	7.0 ± 0.72^{def}	5.70 ± 0.49^{h}	6.5 ± 0.60^{d}
E_2		6.04 ± 0.39^{ef}	7.20 ± 0.70^{g}	6.64 ± 0.67^{f}	5.66 ± 0.40^{h}	6.06 ± 0.78^{e}
E_3		5.92 ± 0.47^{f}	7.09 ± 0.60^{g}	6.70 ± 0.52^{ef}	5.53 ± 0.44^{h}	6.03 ± 0.74^{e}

* All values are mean of fifteen observations±standard deviation.

* Means having different superscripts differ significantly in each column ($p<0.05$).

Table 4: Nutrient composition of control snack bar (A_3) and BRP incorporated snack bar (D_3).

Nutrient	Control bar (A_3)	BRP incorporated bar (D_3)
Moisture (%)	3.0 ± 0.0^{b}	4.5 ± 0.0^{a}
Total ash (%)	2.09 ± 0.00^{b}	3.09 ± 0.00^{a}
Crude protein (%)	12.44 ± 0.33^{a}	9.81 ± 0.11^{b}
Crude fat (%)	17.41 ± 0.14^{a}	14.33 ± 0.28^{b}
Crude fiber (%)	6.50 ± 0.1^{NS}	6.43 ± 0.05^{NS}
Carbohydrate (%)	65.13 ± 0.29^{b}	68.26 ± 0.46^{a}
Energy (Kcal/100 g)	466 ± 0.73^{a}	441 ± 1.43^{b}
Calcium (mg/100 g)	194.83 ± 1.08^{a}	180.47 ± 1.03^{b}
Iron (mg/100 g)	4.33 ± 0.34^{a}	3.39 ± 0.07^{b}
Total phenols (mg GAE/100 g)	201.93 ± 4.03^{b}	228.24 ± 3.12^{a}
Flavonoids (mg RE/100 g)	170.36 ± 4.24^{b}	252.60 ± 4.50^{a}
Total antioxidant activity (mg TE/100 g)	610.36 ± 5.77^{b}	635.94 ± 3.81^{a}
Folic acid (µg/100 g)	104.74 ± 1.04^{NS}	$107.32\ \pm1.56^{NS}$

* All values are average of triplicate observations±standard deviation.

* Means having different superscripts differ significantly in each row ($p<0.05$), NS: Non-Significant difference.

(35 Kcal) and minerals *viz*. calcium (17.28 mg/100g), iron (0.76 mg/100g) (Longvah *et al*., 2017). Therefore, incorporation of 15% BRP resulted in significantly higher ($p<0.05$) moisture, ash and carbohydrate content in D_3 snack bar (Table 4). High total dietary fiber content of BRP which allows good water holding capacity (Kohajdová *et al*., 2018) may be the suggestive of higher moisture content in D_3 snack bar. BRP incorporation also increased total phenol, flavonoids and antioxidant activity significantly ($p<0.05$) in D_3 snack bar, which may be elucidated by the fact that beetroot is the richest source of phenols (169.41 GAE mg/ 100 g) and antioxidant activity (125.10 TE mg/100 g) among all the roots and tubers (Sreeramulu and Raghunath, 2010). In a similar study, beetroot juice alone significantly affected the total phenol and antioxidant activity of beetroot and ground nut meal incorporated pasta (Mridula *et al*. 2016). On the contrary, A_3 control bar, prepared with comparatively higher amount of flax seed and bengal gram (24 g each), had significantly higher ($p<0.05$) crude protein and fat content than D_3 snack bar. Bengal gram is a good source of protein (18.77%) while flax seeds are considered rich in both protein (18.55%) and fat (35.67%) (Longvah *et al*., 2017) which in turn resulted in higher protein and fat content in A_3 control bar. However, the crude fibre and folic acid content were found comparable in both the snack bars. Ingle *et al*. (2017) and Reddy *et al*. (2014) developed cookies with 15% of BRP and extruded snacks with 20% BRP, respectively and reported similar results for nutrient composition.

CONCLUSION

The present study revealed that snack bar prepared with 15% of BRP was the most acceptable among all the snack bars on the basis of textural and sensory evaluation. Also, incorporation of 15% BRP resulted in improved nutrient profile (ash, carbohydrate, folic acid, antioxidants content) of snack bar, which validates great potential of beetroot as a functional food. Keeping in view all these facts, 15% of BRP with other ingredients may be considered for nutritious snack bar formulation at commercial level. Being rich in antioxidants, BRP incorporated snack bars can also be offered to the patients with hypertension and atherosclerosis to ascertain its benefits in such clinical conditions.

Conflict of interest: None.

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