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Preparation and Quality Evaluation of Flaxseed Incorporated Cereal (Oat) Bar

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A study was carried out to prepare cereal bars incorporated with flaxseed rich in nutritional and sensory characteristics which are convenient to carry and consume as a snack. Full fat roasted flaxseed flour was incorporated along with commercially available instant oat flakes at the rate of 5, 10, 15 and 20% to prepare Cereal (Oat) bar. Effect of flaxseed flour incorporation was studied in proximate composition, calcium, iron and phosphorus content of cereal bar. The addition of flaxseed flour increased ($p<0.05$) the nutritional value of the cereal bar in terms of crude protein, crude fat, crude fiber and total ash however, the carbohydrate content significantly decreased. Sensory evaluation of cereal bars were carried out in terms of appearance, color, odor, taste, texture and overall acceptability. Cereal (Oat) Bar prepared by incorporating 10% flaxseed flour was found to be significantly ($p<0.05$) superior from sample with no flaxseed flour in terms of texture and overall acceptability.

Key words: Cereal bar, Flaxseed (*Linum usitatissimum*), Oat (*Avena sativa)*, Shelf life

Introduction

Cereal bars are products obtained from the compression of cereals, containing dried fruits, nuts, flavorings and binder ingredients. They are one of the ready-to-eat convenient products occupying larger space in the consumer market which not only satisfy the hunger, but prove as a quality source of nutrients and a convenient means of replacement of a meal (Padmashree, Sharma, & Govindaraj, 2013). Cereal bars normally contain sugars as main ingredient, which act as binder and sweetener. Texture remains chewy without being sticky, hard or crumbly. They can be fortified with vitamins, minerals and dietary fiber to make them into a wholesome food. Ingredients like dry fruits, fruit concentrates, oat products, wheat flakes etc. could be incorporated to prepare a variety of cereal bars (Pallavi, Chetana, Ramaswamy, & Reddy, 2015). Cereal bars are considered healthy foods because they are generally rich in fiber and low in fat (Khouryieh & Aramouni, 2013).

Among cereals, oats (*Avena sativa L.*) is the most widely used to prepare cereal bars due to its high content and quality of protein, predominance of unsaturated fatty acids and composition of dietary fiber (Munhoz, Nozaki, Guimarães, & Argandoña, 2014). Oat is considered to be a potential source of low cost protein with good nutritional value. Oat has a unique protein composition along with high protein content of 11–15 % (Rasane, Jha, & Sharma, 2015).

Among the functional foods, flaxseed (*Linum usitatissimum*) has emerged as a potential functional food being good source of alpha-linolenic acid, lignans, high quality protein, soluble fiber and phenolic compounds (Kajla, Sharma, & Sood, 2015). An analysis of brown Canadian flax averaged 41% fat, 20% protein, 28% total dietary fiber, 7.7% moisture and 3.4% ash. Flaxseed as a nutritional additive for the preparation of certain dietary items like baked products, ready to eat cereals and fiber bars having good health impacts has been widely recognized in all parts of the world (Mervat, Mahmoud, Bareh, & Albadawy, 2015). Flax has been described as a "remarkably stable product". Freshness can be maintained by storing flax away from air and light. Placing whole flax seeds and milled flax in the freezer or refrigerator prolongs freshness (Morris, 2007).

Nepalese diet usually consists of cereals containing high proportion of carbohydrates but not enough protein, dietary fiber and other micro nutrients (Devkota, De, & Sathian, 2015). Though flaxseed is great source of plant based protein, fiber and minerals, it is considered to be edible only from farmers' perspective particularly among the poor in Nepal. Thus, preparation of cereal bar with the incorporation of flaxseed can be a better approach towards utilizing the locally available and nutritionally rich plant seeds and to prepare a convenient and healthy snack for consumers rich in protein, fiber and minerals.

Materials and methods

Raw materials collection

Instant white oats and jaggery used for cereal bar preparation were procured from the local market, Kathmandu, the capital of Nepal whereas flaxseed sample (brown variety) was collected from Kapilvastu district, the terai region in Southern Nepal. The packaging material was purchased from the local market of Kathmandu. The whole experiment was carried out in the laboratory of Padmashree International College, Kathmandu, Nepal.

Chemicals

All the chemicals were of analytical grade and were provided by Padhmashree International College. Chiefly, the sodium hydroxide pellets used during the experiment were from Thermo Fisher Scientific India Pvt. Ltd. with specification of 97% minimum assay. Petroleum ether for fat extraction was from Finar Limited with boiling point (95%) of 60-80°C.

Flaxseed flour preparation

The flaxseed used during the study was made free of foreign materials (e.g. chaff, mustard seed, and stone) manually and then cleaned with water. Cleaned flaxseed sample was

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sundried (about 4 hours) to remove the moisture present. Then, the flaxseed sample was roasted for 7 minutes time in a pan at medium flame with frequent stirring until there was warm roasted aroma in the air with popping sound. Then it was cooled at room temperature. After that, the roasted flaxseed sample was ground in a grinder to make flaxseed flour of small particle size (1.18 mm mesh).

Method of cereal bar preparation

Different concentration of flaxseed flour (5%, 10%, 15% and 20% of total mixture) was added with instant oats in the jaggery syrup to prepare four different samples of cereal bar along with the control sample having no flaxseed flour. Proportion of flaxseed flour in the mixture was selected on trial basis. Above, 20% proportion of flaxseed in the mixture, taste of bar was found to be unacceptable. Initially, flaxseed flour, instant oats and jaggery were weighed accurately. The instant oats were roasted for 2 minutes under medium heat in a pan for the cooked flavor before mixing with the jaggery syrup. The jaggery syrup solution was prepared to use as a sweetener as well as binding ingredient in the bar preparation. For 1000g of total mixture, 50% jaggery (excluding water addition) was used while concentration of flaxseed flour and oats was varied. The syrup solution was prepared at first in the ratio of 1:2 (Calculated Jaggery (g) added in water (ml)) and stirred uniformly in medium flame until jaggery completely dissolved in water. Then, the jaggery solution was filtered through clean muslin cloth to remove the suspended particles present in jaggery. After that, the filtered jaggery solution was stirred continuously in a pan under medium flame to a temperature of 105°C until formation of thick consistency with a brix value of 82-85° Bx. The consistency of syrup was determined after performing a trial method where the binding of ingredients was better. When the consistency of the syrup was achieved, the roasted flaxseed flour was added to the syrup along with the addition of oats as per different samples. The mixture was mixed uniformly with the spatula. Then, the mixture was spread uniformly on a flat tray lined with butter paper and compressed manually. The mixture was cooled at room temperature and then cut manually with knife to obtain rectangular shaped cereal bar (10cm x 4cm x 1cm). The cut cereal bars were packed individually in Polyethylene package.

Analysis of cereal bar

The chemical analysis as well as sensory evaluation was carried out for all the five formulations of cereal bar. Sample A (Control Sample) consists of 0% flaxseed flour, Sample B consists of 5% flaxseed flour, Sample C consists of 10% flaxseed flour, Sample D consists of 15% flaxseed flour and Sample E consists of 20% flaxseed flour. Cereal bars were crushed in a grinder for chemical analysis.

Moisture content, crude fat, crude protein, crude fiber and total ash were determined according to Official Methods of Analysis AOAC International (AOAC, 2005). Carbohydrate of Cereal bar was determined by difference method (Ranganna, 2011). The calcium, phosphorus and iron content of cereal bars were determined by Spectrophotometer (AOAC, 2005).

Sensory evaluation of samples

All the prepared cereal bar samples (Sample A, B, C, D and E) were evaluated by organoleptic process by a panel of 10 semi trained members using a 9- point Hedonic rating scale method (Ranganna, 2011).

Statistical analysis

The analyses were conducted and triplicate data were observed for each sample. All the data were analyzed by using ANOVA (Analysis of Variance) using the statistical program SPSS 16 programming at 5% level of significance. Duncan test was carried out to determine whether the samples were significantly different from each other.

Results and Discussions

Proximate analysis of cereal bars

Proximate composition of cereal bar incorporated with flaxseed flour is given in Table 1.There was no significant difference in moisture content between the flaxseed-incorporated samples. Similar report was observed in the development of omega-3 rich energy bar with flaxseed (Mridula, Singh, & Barnwal, 2013). The crude protein content of different cereal bar samples ranged from 7.41 ± 0.28 to 9.42 ± 0.23% which was increased with increasing level of flaxseed. Similarly, the crude fat content of cereal bar increased significantly with increasing level of flaxseed ($p < 0.05$). This might be due to high fat content of flaxseed in comparison to oats. Significant increment in total ash and crude fiber was observed from sample A to sample B. The reason for increasing content of crude protein, crude fat, crude fiber and total ash of cereal bar samples in table might be due to high protein content, fat content, minerals and fiber content of flaxseed, which increased, with the increasing level of flaxseed. Same trend was observed in the development of omega-3 rich energy bar with flaxseed (Mridula, Singh, & Barnwal, 2013). Likewise, Fortification of biscuit with flaxseed resulted in increased protein, fat, ash and dietary fiber content (Masoodi & Bashir, 2012).

Table 1

Proximate analysis of prepared cereal bar (in % dry basis)

Sample	Moisture	Crude protein	Crude fat	Total Ash	Crude fiber	Carbohydrate
A	3.88^{a}±0.02	7.41^{a}±0.28	3.89^{a}±0.07	2.41^{a}±0.04	0.71^{a}±0.03	85.58^{a}±0.21
B	4.03^{ab}±0.01	7.72^{a}±0.25	6.96^{b}±0.18	2.63^{b}±0.02	1.46^{b}±0.12	81.23^{b}±0.11
C	4.06^{ab}±0.07	8.47^{b}±0.08	7.73^{c}±0.05	2.75^{bc}±0.03	1.67^{b}±0.08	79.38^{c}±0.24
D	4.16^{ab}±0.05	9.13^{c}±0.06	9.15^{d}±0.08	2.88^{c}±0.03	2.32^{c}±0.05	76.52^{d}±0.19
E	4.35^{b}±0.24	9.42^{c}±0.23	10.72^{e}±0.33	2.93^{c}±0.84	2.43^{c}±0.02	74.50^{e}±0.46

*The values in the table are the mean values ± standard error of triplicate analysis. All the parameters are in dry basis except moisture. Means bearing different superscripts in a column are significantly different from each other- Duncan ($p<0.05$).

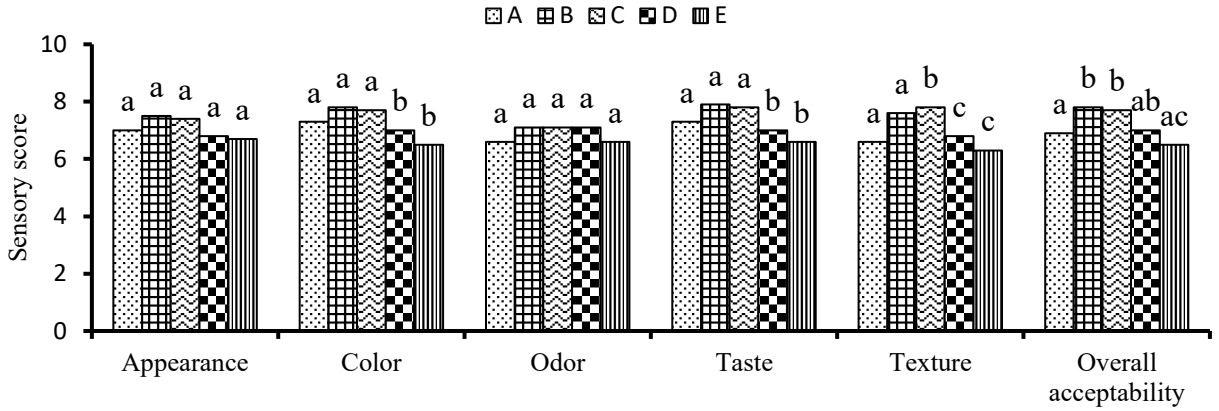

Figure 1. Mean sensory score for cereal bar samples (The alphabet A, B, C, D and E represent the cereal bar samples incorporated with flaxseed flour in proportion of 0%, 5%, 10 %, 15% and 20% respectively. Similarly, the alphabet a, b and c represent the subsets to analyze whether the formulated cereal bar samples were significantly different or not.)

However, the carbohydrate content of different samples of cereal bar significantly decreased from sample A to sample E, the highest content present in control sample and lowest in sample E. The carbohydrate content was high in every sample, which may be due to use of jaggery as binding and sweetening agent.

Mineral analysis of cereal bars

All the samples of cereal bar incorporated with flaxseed flour were analyzed for mineral content including the control sample. Table 2 shows the mineral content of different samples of cereal bar having different concentration of flaxseed flour.

Significant increment in calcium and phosphorus content was observed in sample C whereas significant increment in iron content was observed from sample B ($p<0.05$). The reason for increase in mineral content might be due to high mineral content in flaxseed.

Sensory evaluation of cereal bars

The cereal bars prepared were analyzed for sensory evaluation using 9 point Hedonic Rating Test ranging from 1 (dislike extremely) to 9 (like extremely). Sensory analysis was carried out for all five formulations. Sensory evaluation was carried out with respect to appearance, color, Odor, taste, texture and overall acceptability. The result of sensory analysis is presented in Figure 1.

The panelist quite liked the appearance of the bar. However, no significant difference was observed between the cereal bar samples ($p>0.05$) in terms of appearance. This concludes the fact that flaxseed incorporation had no significant effect in the appearance of the cereal bar ($p<0.05$). With the increasing flaxseed incorporation, the color of the cereal bar became more dark brown which became significant in sample D. The dark brown color is due to the color of flaxseed flour incorporated. Pigments such as leutin/ zeaxanthin in flaxseed make it dark brown (Ganorkar & Jain, 2014). However, no significant difference in color was observed among the samples A, B and C ($p>0.05$). Similarly, there was no significant difference in odor between the cereal bar samples ($p>0.05$).

The cereal bars were found to be sweet in taste. The sweet taste was contributed by the use of jaggery as sweetening and binding agent. There was no significant difference in taste between samples A, B and C ($p>0.05$). On increasing the flaxseed concentration in the bar, the nutty flavor of flaxseed became more prominent in the product significantly in sample D and E. The texture of flaxseed flour incorporated samples was found to be chewy. The chewiness may be contributed to the fat content of flaxseed flour used. Significant difference in texture of cereal bar was observed in samples C, D and E with respect to control sample ($p<0.05$). While comparing with control sample, significant difference was observed in sample B and C in terms of overall acceptability ($p<0.05$). However, there is no significant difference in overall acceptability among samples B, C and D.

Table 2
Mineral content of prepared cereal bar (in mg/100g, dry basis)

Sample	Calcium	Iron	Phosphorus
A (Control)	$51.45^{a}\pm1.60$	$5.48^{a}\pm0.01$	$188.19^{a}\pm0.07$
B	$55.26^{a}\pm3.47$	$5.79^{b}\pm0.01$	$188.42^{a}\pm0.07$
C	$66.74^{b}\pm1.83$	$6.28^{c}\pm0.01$	$205.38^{b}\pm0.07$
D	$80.00^{c}\pm1.22$	$7.35^{d}\pm0.01$	$239.29^{c}\pm0.13$
E	$81.45^{c}\pm0.52$	$7.55^{d}\pm0.15$	$242.72^{d}\pm0.00$

*The values in the table are the mean values ± standard error of triplicate analysis. All the values are in dry basis. Means bearing different superscripts in a column are significantly different from each other- Duncan ($p<0.05$).

Conclusions

From sensory evaluation, cereal bars incorporated with flaxseed flour were found to be acceptable by the sensory

panelists. In most of the sensory parameters, samples up to 10% flaxseed flour incorporation were better liked by sensory panelist with significant difference ($p<0.05$) from control sample in terms of texture and overall acceptability. In terms of nutritional quality, flaxseed incorporation increased the protein, fat, ash, fiber, calcium, iron and phosphorus content including the increasing darker color of the cereal bar with increasing level when compared to the control sample. Shelf life of cereal bar can also be studied until the product deteriorates by studying the microbial changes or sensory attributes with storage time. It can also be studied by accelerating the storage condition of the product such as temperature and relative humidity.

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