Chia seed based nutri bar: optimization, analysis and shelf life

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In this study, chia seeds were incorporated for the development of an optimized nutri bar. Different formulations containing 5, 10, 15 and 20% of chia seed flour were evaluated. The developed bar was analysed for its nutritional quality, sensory attributes, physiochemical properties and storage quality. The results revealed that the 10% incorporation of chia seed with protein content 3.72±0.11%, crude fibre 10.52±0.08%, ash 2.0%, crude fat 3.52±0.19%, carbohydrate 51.00±0.24% and antioxidant activity 32.23±0.69% inhibition was highly acceptable in terms of sensory attributes. The shelf life study revealed that the nutri bar when stored at temperature at 10°C sealed in low density polyethylene bags tend to have more shelf stable. The gross energy of the chia seed nutri bar was calculated to be 250.52±0.63% kcal.

Keywords: Diet supplement, energy, rapidly consumed, antioxidant, chlorogenic acid

Chia (Salvia hispanica L.) is a herbaceous plant, cultivated annually, and indigenous to Southern Mexico and Northern¹. It has a high oil content (39%), is rich in polyunsaturated fatty acids, mainly omega-3 fatty acids (linolenic acid, 68) and omega-6 (linoleic acid, 12–21%) (ref. 2) and has protein content of 15–25% (ref. 3). Moreover, the fibers present, (18–30%) potentiate the use of chia in the production of functional foods⁴ and the dietary fiber (over 30% of the total weight), both soluble and insoluble, which are important components
of the human diet; and proteins of high biological value around 19% of the total weight. In addition, the seed contains natural antioxidants such as phenolic glycoside-Q and K, chlorogenic acid, caffeic acid, quercetin and kaempferol which protects consumers against adverse conditions, such as some cardiovascular diseases and few types of cancers; as well as supplying vitamins and minerals.

A non-cooked bar is substantially non-perishable, readily portable and could be rapidly consumed. In order to meet nutritional needs, fortified non-cooked bars were introduced which provided a portion of the daily requirement of minerals and vitamins. Consumers demand and desire the health foods, which are portable, convenient and proportioned as well. Often, many options aren’t available that are minimally processed, rich in nutrients and tastes good. The food bars are snacks of good sensory and nutritional characteristics due to their high carbohydrates, proteins, lipids and minerals contents. This can be recommended to pregnant and lactating women or women of childbearing age as this is rich in calcium and iron. Nutri bars are diet supplement and mostly consumed by people who want to maintain their calorific needs. There are various bars available in the market such as energy bar, snack bar, granola bar, protein bar and other nutri bars. Nutri bars were initially marketed to athletes as a source of energy. However, the growing luxury groups and health-conscious consumers had increased the sales performance of nutri bars. Due to the growing consumer demand for natural, convenient and nutritious food products, there is a need to modify, innovate and improve the nutritive composition of nutri bars for increased health benefits.

Therefore, in the present study, chia seed flour has been incorporated for the formulation of nutri bar with the ingredients like dates and sesame seeds. The aim of the study was supplementing chia seeds for its high PUFA, protein and dietary fiber content in
the nutri bar and assessment of its nutritive quality, antioxidant capacity, functional properties like water and oil absorption capacity, sensory acceptability and shelf life.

Materials and methods

Materials

Dates, sesame seeds and chia seeds used for the preparation and LDPE bags and card board boxes used for packaging of nutri bar were purchased from local market of Jalandhar, Punjab, India. The chia seed nutri bar was prepared by modifying the method described by Ateequddin and Ingle⁹ as shown (Figure 1). The different formulations of chia seed nutri bar were prepared as shown (Table 1).

Methods

Nutritional analysis of Nutri bar

The nutri bar was analysed for its chemical composition (Moisture, crude protein, crude fat, ash and Crude fibre) using methods by AOAC¹². Oven dry method (AOAC¹² method 977.11) was referred to calculate moisture content. Kjeldahl’s method (AOAC method 955.04) was referred to analyse crude protein. Soxhlet method (AOAC¹² method 960.39) was used for crude fat determination. Dry ashing method (AOAC method 923.03) was used to determine ash content, and gravimetric method (AOAC¹² method 991.43) was used to examine crude fibre and the carbohydrate content was determined by the difference method¹³.

Gross energy value

The gross energy value of developed nutri bars were determined by using standard factors of 4, 9 and 3.75 kcal/g for protein, fat and carbohydrate, respectively. The calculated energy values were summed up to give gross energy values¹⁴.
**Mineral analysis**

For sodium and potassium estimation, an aliquot of ash (0.01mg/ml) solution was diluted so that it contains less than 10ppm of sodium and potassium. Sufficient HCl was added so that the concentration of the acid is same as that in the standard solution. The diluted extract was atomised in a calibrated flame photometer with the wavelength dial set at 589 nm and transmittance set at 100% for the top standard solution of sodium and at the 768 nm and transmittance set at 100% for the top standard solution of potassium. The concentration were noted from the standard curve by applying the following formula (1) and (2).

**Calculation**

\[
\text{Sodium} \left( \frac{\text{mg}}{100\text{g}} \right) = \frac{\text{ppm found from the standard curve} \times \text{volume made up} \times \text{dilution} \times 100}{\text{Weight of sample} \times 1000} \tag{1}
\]

\[
\text{Potassium} \left( \frac{\text{mg}}{100\text{g}} \right) = \frac{\text{ppm found from standard curve} \times \text{volume made up} \times \text{dilution} \times 100}{\text{weight of sample} \times 1000} \tag{2}
\]

**Physical properties of Nutri bar**

The water absorption capacity was determined by taking 1 g of sample mixed in 15 ml of distilled water. The mixture was transferred to a 25 ml of centrifuge tube and agitated on a votex mixer for 2 minutes and then centrifuged at 4000 rpm for 20 minutes. The supernatant was discarded and the weight of the tube was retaken and applied on the formula mentioned (3). Similarly, for oil absorption capacity, water was replaced by the oil and the same procedure was followed and values were marked in the following equation (4).

\[
\text{WAC} = \frac{\text{Weight of centrifuge tube} + \text{weight of sediment} - \text{weight of empty tube}}{\text{weight of sample}} \tag{3}
\]

\[
\text{OAC} = \frac{\text{Weight of centrifuge tube} + \text{weight of sediment} - \text{weight of empty tube}}{\text{weight of sample}} \tag{4}
\]
Free Radical Scavenging Activity (FRSA) of nutri bars

Free radical scavenging activity (FRSA) was measured as per the method of a 1gm of sample extracted with 5ml of 80% methanol. The mixture was than centrifuged at 1000 rpm for 15 min and the supernatant was collected. DPPH (2, 2-Diphenyle- 1- picrylhydrazyl) was used as a source of free radical. A quantity of 3.9 ml of 6 * 10-5 mol/l. DPPH in ethanol was put into a test tube with 0.1ml of sample extract and the decrease in absorbance was measured at 517nm for 30min or until the absorbance become steady. Ethanol was used as a blank and the following formula (5) was used.

\[
\text{Antioxidant activity (\%) } = \frac{A_0}{A} \times 100
\]

where, \(A_0=\) Absorbance of DPPH as blank

\(A =\) Absorbance of sample

Organoleptic evaluation of nutri bar

Sensory characteristics of nutri bar samples were evaluated for different sensory attributes by a group of 50 semi-trained panellists (25 males and 25 females of age 20-35 years) using 9 point hedonic scale. Nutri bars were coded randomly from 101 to 106 to avoid any preassumptions. The data regarding sensory panel screening and evaluation were collected to eliminate errors in the process. Sensory attributes included colour and appearance, taste, texture, mouth feel and overall acceptability. The panel members chosen were healthy and free from any diseases. A score card consisting of preference rating from extremely liked to disliked extremely with the given instructions were given to panel members for the assessment of their liking and preferences. The freshly prepared nutri bars were served to panellist in odourless plastic containers with a glass of water for rinsing mouth in between the
samples. The area used for sensory analysis was isolated and aroma free. The sensory panel was trained using commercially available nutri bars containing peanuts, to accustom them to the food type. The scores received while organoleptic evaluation were statistically analysed by ANOVA \(^{18,19}\).

**Shelf life analysis**

Shelf-life analysis was performed on the most acceptable treatment after organoleptic evaluation. Packed nutri bars fortified with chia seeds were stored at different temperatures for the shelf life study (10, 25, and 37°C for 28 days). The samples were withdrawn at an interval of 7 days during storage and analyzed for hydroxyl methyl furfural (HMF), thiobarbituric acid test (TBA) and free fatty acid content (FFA) test as per the procedures used by Rasane et al.\(^ {20}\).

**Statistical analysis**

All the tests were carried out in triplicates and the mean were presented along with standard deviation. The significant difference of mean values and product optimization was performed with Duncan’s Multiple Range test and Post hoc test using SPSS 16.0 software (SPSS) Italia, Bolognam, Italy at a significance level of 5%.

**Results and discussion**

**Nutritional analysis**

Nutritive composition of nutri bar incorporated by chia seeds (CS) is given in the Table 2. It was observed that moisture content decreased with the increase in chia seeds composition\(^ {21}\), owing to low moisture content of chia seeds, increasing the shelf-life of the product. There was a gradual increase in the amount of protein concentration as increase in the concentration
of chia seeds due to the high amount of protein present in chia seeds (21.52 g/100 g)\textsuperscript{22},
despite of low content of protein in dates (2 g/100 g)\textsuperscript{23}.

Similarly, ash content increased with increasing the chia seed concentration from the range
1.60±0.02 (control) to 3.00±0.04 (20\% incorporation of chia seeds). The increased trend of
chia seed nutri bar is due to high mineral content in the chia seeds especially Mg, Ca, Fe, Zn,
Mg, Co and Se \textsuperscript{24}. Although the fat content of dates is less (0.14 g/100 g)\textsuperscript{3} however, due to
the high content of fat in chia seeds (24.83\% per 100 gm)\textsuperscript{22}, the fat of nutri bar ranged from
2.0 to 4.5\%. The fibre content varied from 7.87± 0.13 to 13.28 ± 0.08 in the nutri bar which
shows the high fibre content in the product. Chia seeds comprised of 56.4 g/100 g of dietary
fiber which imparts good water holding capacity and high emulsifying activity\textsuperscript{24}. The similar
results were reported by Romankiewicz et al.\textsuperscript{25} where they studied the effect of chia seeds
addition on quality and nutritional value of white bread. They observed that the dietary fibre
content increases as high as 7.19\% with 8\% chia seed addition. The energy content was
correspondingly increasing from 227.03 to 272.53 kcal with increasing concentration of chia
seed which shows that chia seeds have high nutrient density.

\textit{Mineral analysis}

The concentration of sodium and potassium in chia seeds were 71.9 and 635 mg/100 g, respectively, which imparts the properties like lowering of blood pressure and maintaining
the electrolytes\textsuperscript{26}. Table 3 shows the amount of sodium and potassium present in the nutri
bars which are in agreement with the results given by Kibui et al.\textsuperscript{27} where they have prepared
yoghurt enriched with chia seeds.

\textit{Physico-chemical properties}
The functional properties play a vital role in the manufacturing of the product. The nutri bars were analyzed for their functional properties including water absorption and oil absorption capacity (OAC and WAC) as shown (Figure 2). The OAC and WAC depends on the amino acid composition, surface polarity and protein conformation like intrinsic factors\textsuperscript{28}. The water absorption capacity increased significantly (p<0.05) but not much difference was observed in between control and 5% chia seed incorporation and in between 15 and 20% chia seed incorporation. The value ranged from 0.71±0.71 (Control) to 1.67±0.15 (20% incorporation) that signifies that nutri bar tend to absorb more water with increase in the concentration of chia seeds. This is due to the high water retention capacity and high fiber content of chia seeds. OAC is highly essential characteristic for the development of food product and longer storage life. The decrease trend observed for oil absorption capacity for nuti bars were in agreement with the results shown by Haripriya and Aparna\textsuperscript{28} where the studied they effect of roasting on chia seed based instant soup mix.

*Free Radical Scavenging Activity (FRSA) of nutri bars*

Antioxidant capacity is one that quantifies the ability of complex biological sample to quench DPPH free radicals\textsuperscript{29}. The antioxidant activity significantly (p<0.05) increased by chia seed incorporation as shown (Figure 3). The results were in accordance with Costantini *et al.*\textsuperscript{30} in their study of incorporation of chia seed flour in white bread. They reported that tartary buckwheat flour and chia seed incorporation by 10% increased the antioxidant activity by 75% in the prepared bread.

*Organoleptic evaluation of nutri bar*

Sensory acceptance of chia seed nutri bars were determined by the changes in terms of color and appearance, taste, aroma, texture, mouthfeel and overall acceptability. Highest values were observed for the 10% incorporated chia seed nutri bar and the values reported for color
and appearance, taste, aroma, texture and overall acceptability were 7.18±0.76, 7.24±0.58, 8.38±0.82, 6.75±0.43 and 6.35±0.55, respectively as shown (Figure 4). However, the lowest score were observed for 20% incorporation of chia seeds i.e 6.35±0.55. The overall scores increased significantly (p<0.05) from 7.18±0.76 to 8.38±0.82 in case of control, 5% and 10% incorporation and started decreased from 30 and 40% incorporation with the values of 6.75±0.43 and 6.35±0.55, respectively. These results are close to that obtained from Zaki\textsuperscript{31} who studied the effect of adding chia seeds in camburger. He reported that 3% chia seed addition in the camburger received the highest scores in comparison to other samples.

\textit{Shelf life evaluation}

Food packaging has a vital role in analysing the shelf life of foods as they inhibit the entrance of oxygen and loss and gain of moisture in foods\textsuperscript{32} which shows that selection of suitable packaging material is important to ensure the better keeping quality of product during storage to prevent oxidation of lipids. Lipid oxidation and browning are the important phenemenon occurring in food systems and that depicts the food deterioration during storage and processing. In the present study, the lipid oxidation of optimised nutri chia seed bars was studied by tracking the changes that took place in free fatty acids (FFA), Thiobarbituric acid (TBA) and browning was studied by analysing Hydroxyl methyl furfuryl (HMF) in the most acceptable treatment i.e 10% chia seed incorporated nutri bar on the basis of organoleptic evaluation. The result shown (Table 4), stated the change in moisture content, HMF, TBA and FFA values after 28 days of storage for 10% added chia seed nutri bar. The moisture content increased significantly at all the temperatures in the span of 28 days in both ziplock pouches and cardboard boxes. The highest moisture content of 46.89±0.17 was observed in the sample stored in cardboard boxes at 25°C after 28\textsuperscript{th} day of storage. The results were in accordance with Padamashree et al.\textsuperscript{33} who developed choco quinoa nutri bar and observed significant increase (p<0.05) in moisture content in the storage period of 9 months. The
increase in the moisture content (measured by oven drying procedure) of nutri bar was observed from 7.33 to 8.21, 7.70 and 7.51 packaged in polypropylene (PP), metalised polyster (MP) with vaccum and without vaccum respectively.

The HMF is the product formed as an intermediate of the Maillard reaction or caramelization of sugar at high temperature\textsuperscript{34}. The HMF values showed significant increase (p<0.05) in the values at 37, 25 and 10°C in the nutri bar stored in zip lock pouches as well as cardboard boxes. The highest value of 20.84 ± 1.83 was observed in the samples stored in cardboard boxes at 37°C. Similar result has been reported by Mesias et al.\textsuperscript{35} in their work of chia seeds biscuits. Their results showed a significant increase from 22mg/kg (0% chia flour) to 71 mg/kg in case of highest chia seed incorporation (20%) in wheat flour biscuits. They suggested the maximum incorporation of chia seed by 10% as the more incorporation beyond this level has lead to the formation of acrylamide, HMF and furfural.

High TBA values are associated with lipid oxidation due to processing conditions, packaging and storage and also because of high fat content\textsuperscript{36}. Similary, the TBA values increased significantly (p<0.05) from the 0\textsuperscript{th} to 28\textsuperscript{th} day at different temperatures. The nutri bar stored at 25°C showed the highest highest values were recorded at 25°C stored at 13.40±0.05 mg malenaldehyde/kg. The results were in agreement with Scapin et al.\textsuperscript{37} in their study of effect of chia seed addition in pork sausage. They stated the increase in TBARS value from 0.61±0.02 to 1.12±0.03 in the highest incorporation of chia seed extract (2%) in the storage period of 28 days.

For FFA values, a significant increase (p<0.05) was observed at all the storage temperature in both ziplock as well as cardboard boxes. The lowest degradation was observed in cardboard boxes stored at 37°C by the value of 1.80±0.13 and highest was observed in bars stored at 25°C by the value of 6.72 ± 0.44 in cardboard boxes. Ryavanki and Hemalatha\textsuperscript{38}
showed the similar trend in the shelf life study of low glycemic index snack bar prepared from red sorghum flakes. They reported significant increase in the free fatty acid values 1.36±0.42 to 6.16±0.45% oleic acid and at high temperature and at ambient temperature the values ranged from 1.36±0.42 to 2.37±0.25%.

Conclusion

The study demonstrated that date and chia seeds can be used to formulate chia-date bar which improves protein, carbohydrate and crude fibre content. The developed bar was assessed for nutritional quality, sensory attributes, physiochemical and shelf life analysis. The optimised product 10% (dates 90 g and chia seed flour 10 g) revealed the nutritional content of the nutri bar: protein content (3.72%), crude fibre content (10.52%), potassium (37.33 ppm), ash content (2.0%), crude fat (3.52%) and antioxidant (32.23±0.69%). The organoleptic evaluation results showed the highest scores of 8.38±0.82 for 10% chia seed flour incorporation in the nutri bar which was further carried for shelf life analysis. The results for shelf life analysis showed the significant degradation in the span of 28 days by significant increase (p<0.05) in moisture, TBA, HMF and FFA values at different temperatures and packaging material. The suitable temperature for the storage of nutri bar is 10°C in LDPE pouches.
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Table 1. Formulations of nutri bar incorporated with chia seeds powder.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Control</th>
<th>CSN₁ (5%)</th>
<th>CSN₂ (10%)</th>
<th>CSN₃ (15%)</th>
<th>CSN₄ (20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dates</td>
<td>100 g</td>
<td>95 g</td>
<td>90 g</td>
<td>85 g</td>
<td>80 g</td>
</tr>
<tr>
<td>Chia seed powder</td>
<td>--</td>
<td>05 g</td>
<td>10 g</td>
<td>15 g</td>
<td>20 g</td>
</tr>
<tr>
<td>Sesame seeds</td>
<td>05 g</td>
<td>05 g</td>
<td>05 g</td>
<td>05 g</td>
<td>05 g</td>
</tr>
</tbody>
</table>
### Table 2. Nutritive composition of chia seeds nutri bar.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
<th>Fat (%)</th>
<th>Protein (%)</th>
<th>Carbohydrate (%)</th>
<th>Crude fibre (%)</th>
<th>Energy (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>44.13±0.31e</td>
<td>1.60±0.02e</td>
<td>2.00±0.05e</td>
<td>2.93±0.04e</td>
<td>49.34±0.33d</td>
<td>7.87±0.13e</td>
<td>227.08±0.64e</td>
</tr>
<tr>
<td>5%</td>
<td>41.93±0.15d</td>
<td>1.80±0.06d</td>
<td>2.50±0.13d</td>
<td>3.25±0.09d</td>
<td>50.52±0.09bc</td>
<td>9.23±0.08d</td>
<td>237.58±0.78d</td>
</tr>
<tr>
<td>10%</td>
<td>39.77±0.15c</td>
<td>2.00±0.04c</td>
<td>3.52±0.19c</td>
<td>3.72±0.11c</td>
<td>51.00±0.24c</td>
<td>10.52±0.08c</td>
<td>250.56±0.63c</td>
</tr>
<tr>
<td>15%</td>
<td>37.50±0.30b</td>
<td>2.60±0.02b</td>
<td>4.00±0.13b</td>
<td>4.27±0.10b</td>
<td>51.63±0.33b</td>
<td>12.03±0.08b</td>
<td>259.60±0.35b</td>
</tr>
<tr>
<td>20%</td>
<td>35.63±0.21a</td>
<td>3.00±0.04a</td>
<td>4.50±0.10a</td>
<td>5.06±0.04a</td>
<td>52.94±0.31a</td>
<td>13.28±0.08a</td>
<td>272.50±0.30a</td>
</tr>
</tbody>
</table>

Values (Mean ± Standard deviation) represented with different small superscript are significantly different (p≤0.05) in a column.
Table 3. Mineral content of nutri bar.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sodium (ppm)</th>
<th>Potassium (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30.33 ± 0.58&lt;sup&gt;e&lt;/sup&gt;</td>
<td>19.33 ± 0.18&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>5 %</td>
<td>36.00 ± 0.21&lt;sup&gt;d&lt;/sup&gt;</td>
<td>30.67 ± 0.53&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>10%</td>
<td>42.33 ± 0.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>37.33 ± 0.27&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>15%</td>
<td>51.67 ± 1.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.33 ± 0.13&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>20%</td>
<td>65.33 ± 0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>48.00 ± 0.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

The values are represented in Mean ± Standard deviation derived for triplicate experiments (n=3). The values denoted with different superscripts differ significantly at \( p<0.05 \) in a column.
Table 4: Shelf life analysis of nutri bar.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Temperature</th>
<th>Packaging material used</th>
<th>0th day</th>
<th>7th day</th>
<th>15th day</th>
<th>21st day</th>
<th>28th day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10°C</td>
<td>LDPE pouches</td>
<td>35.45±0.24</td>
<td>36.93±0.71</td>
<td>38.25±0.21</td>
<td>39.89±0.48</td>
<td>40.13±0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardboard boxes</td>
<td>35.14±0.12</td>
<td>36.33±0.73</td>
<td>37.55±0.67</td>
<td>39.84±0.12</td>
<td>41.49±0.36</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td></td>
<td>LDPE pouches</td>
<td>39.77±0.62</td>
<td>40.39±0.37</td>
<td>42.79±0.69</td>
<td>45.15±0.77</td>
<td>45.98±0.87</td>
</tr>
<tr>
<td></td>
<td>25°C</td>
<td>Cardboard boxes</td>
<td>39.20±0.61</td>
<td>40.89±0.47</td>
<td>41.22±0.33</td>
<td>42.47±0.54</td>
<td>46.89±0.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LDPE pouches</td>
<td>37.27±0.15</td>
<td>39.44±0.67</td>
<td>41.83±0.33</td>
<td>42.15±0.31</td>
<td>43.19±0.34</td>
</tr>
<tr>
<td>Hydroxyl Methyl Furfural (HMF) (µmoles/g)</td>
<td></td>
<td>Cardboard boxes</td>
<td>38.13±0.54</td>
<td>38.93±0.14</td>
<td>40.13±0.37</td>
<td>41.87±0.94</td>
<td>44.65±0.92</td>
</tr>
<tr>
<td></td>
<td>37°C</td>
<td>LDPE pouches</td>
<td>2.59±0.09</td>
<td>6.53±0.04</td>
<td>10.73±0.02</td>
<td>14.98±0.13</td>
<td>19.24±0.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardboard boxes</td>
<td>1.86±0.14</td>
<td>5.82±0.68</td>
<td>10.20±0.08</td>
<td>15.49±0.90</td>
<td>20.84±1.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LDPE pouches</td>
<td>4.10±0.01</td>
<td>7.61±0.11</td>
<td>11.12±0.21</td>
<td>13.40±0.05</td>
<td>14.54±0.11</td>
</tr>
<tr>
<td>Temperature</td>
<td>Packaging Type</td>
<td>Thiobarbituric Acid Test (TBA) (mg malenaldehyde/kg)</td>
<td>Free Fatty Acid (FFA) (% oleic acid)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
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<td>10°C</td>
<td>Cardboard boxes</td>
<td>4.37 ± 0.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.82 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>LDPE pouches</td>
<td>1.74 ± 0.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.35 ± 0.17&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>25°C</td>
<td>Cardboard boxes</td>
<td>1.36 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.97 ± 0.13&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>LDPE pouches</td>
<td>1.80 ± 0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.35 ± 0.44&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>37°C</td>
<td>Cardboard boxes</td>
<td>0.44 ± 0.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.12 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>LDPE pouches</td>
<td>1.35 ± 0.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.35 ± 0.17&lt;sup&gt;a&lt;/sup&gt;</td>
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<sup>a</sup><sup>b</sup><sup>c</sup><sup>d</sup><sup>e</sup> Indicates statistically significant differences between samples.
Figure 1. Process flow chart for the development of chia seed nutri bar.

- Fresh dates were taken and steamed for 5 min. at 62°C in order to remove
- Chia seeds were ground to make its powdered form
- Dates and chia seeds was blended in 90:10 proportion
- Sesame seeds were added to the blend and a mixture was prepared
- Mixture was placed on the stainless steel utensil and 1.5 cm of thickness sheet was made with the help of rolling pin
- Nutri bars were cut with a stainless knife in the length of 7 cm. Each bars of 25 g was packed individually in zip lock pouches and cardboard box at different temperatures (10, 25 and 37°C)
Figure 2. Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of chia seeds nutri bar.
Figure 3. Free radical scavenging activity of chia seeds nutri bar. Values (Mean ± Standard deviation) represented with different small superscript are significantly different (p≤0.05)
Figure 4. Graphical representation of sensory analysis of chia seed nutri bar.