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Quality Analysis of Banana–Oatmeal Energy Bar Enriched with Peanut Butter and Chocolate Chips

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Abstract

This work aimed to prepare an energy bar using ripe bananas, rolled oats, peanut butter and chocolate chips and evaluate its quality. Response Surface Methodology (RSM) with a randomized mixture design was used to create different formulations using Design Expert 13.1.5 software, and 14 formulations were obtained. Formulated samples were subjected to sensory evaluations using 9 points hedonic rating scale. Based on the sensory evaluation, the results indicated that formulations with higher proportions of chocolate chips and peanut butter samples G and L were preferred. Physical properties of the energy bar were measured; the addition of peanut butter and chocolate chips influenced the volume, texture and density of the bars. Potassium, calcium and radical scavenging activity were found to be significantly increased. Data from sensory analysis, physical properties and minerals were statistically analyzed, and means were compared at 5% level of significance.

Keywords: Energy bar, ripe bananas, oatmeal, sensory

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Introduction

Energy bars are convenient, well-sized and nutrient-dense snacks that deliver energy through fats, proteins, and carbohydrates (Gill & Singh, 2020). It contains nuts, seeds, dried fruits, and sweeteners such as sugar or sugar-based binders like honey, caramel, or whey protein solids, along with chemical binders (Chitkara et al., 2017). Chocolate, peanut butter, and fruit bars are favoured alternatives that can substitute sugary junk food in the diet (Rawat & Darappa, 2015). The banana, a large herbaceous plant belonging to the *Musaceae* family, is among the most widely consumed fruits globally. Bananas possess pharmacological properties, including anti-inflammatory, antioxidant, anti-cancer, and anti-diabetic effects. They are commonly used in the production of bread, pasta, candies, and gluten-free products (Afzal et al., 2022). Nutritionally, bananas are an excellent source of potassium and carbohydrates. A medium banana (about 118 g) contains approximately 27 g of carbohydrates—half of which are sugars—3.1 g of dietary fibre, 105 kcal, 422 mg of potassium, and 0.43 mg of vitamin B6. This unique combination of carbohydrates, minerals, and antioxidants makes bananas a valuable food for supporting health during prolonged and intense physical activity (Nieman et al., 2012). Both its ripe and unripe forms contain compounds that neutralize free radicals and have therapeutic effects against diabetes and ulcers (Afzal et al., 2022).

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

Among cereals, oat (*Avena sativa*) is most widely used to prepare cereal bars due to its good quality of protein, about 11 to 15%, unsaturated fatty acids and composition of soluble dietary fibre primarily beta-glucan (Munhoz et al., 2014; Rasane et al., 2015). According to the World Health Organization, oat protein is nearly as high in quality as soy protein, which is considered comparable to the protein found in meat, milk, and eggs (Yan, 2007). Syed et al. (2020) found moisture content 4.2%, ash 1.97%, crude protein 12.6%, crude fat 6.91%, total fibre 13.65% and carbohydrate 55.75%. Oats contain significant amounts of phenolic acids, tocols, sterols, avenacosides, and avenanthramides. Consuming oats has been linked to the prevention of conditions such as dermatitis, atherosclerosis, and various cancers (Paudel et al., 2021). Unlike other cereals, oats have a unique structure where the hull is not attached to the endosperm, and they possess a higher fat content. To unlock its nutritional benefits, heat treatment is used to inactivate enzymes that cause rancidity, and mechanical processing—cutting, rolling, or grinding—to produce oatmeal or ingredients for foods like bread, ready-to-eat cereals, and snack bars (Decker et al., 2014).

The peanut, scientifically known as *Arachis hypogaea* and a member of the Fabaceae family, is the source of peanut butter, which contains fats that serve as an energy source for the body (Chitkara et al., 2017). Shibli et al., (2019) found that the chemical composition depends on the varieties peanut cultivar such as moisture: 5.53±0.20 to 5.93±0.02 %, ash: 2.00±0.11 to 2.17±0.05%, crude fats: 49.80±3.54 to 50.90±0.93%, crude proteins 23.83±1.71 to 26.43±1.15 %, crude fiber: 4.95±0.06 to 8.53± % and total carbohydrate: 13.23±2.20 to 19.42±3.83 %. Peanut butter is produced by grinding dry-roasted peanuts, with occasional additions of seasonings and stabilizers (Chang et al., 2013). Manobanda-Narvaez et al. (2022) have found that 100g of peanut butter contains 22.5 g of protein, 51.10 g of fat, 4.8 g of fibre and 22.3 g of carbohydrate. Shibli et al. (2019) reported the moisture content of peanut butter as 0.038-0.37%, and ash 3.2 -3.27%. Peanut butter an emulsion with water droplets dispersed within an oil phase (Aryana et al., 2000). Over time, oil separation occurs during storage, requiring remixing to maintain quality and prevent rancidity. To stabilize the product, additives are used to inhibit oil separation, enhance texture, prolong shelf life, and preserve freshness, aligning with consumer preferences (Gills & Resurreccion, 2000). Salt is incorporated to improve flavour, while sugar adds sweetness. The characteristic softness and stickiness of peanut butter result primarily from its high protein content, which absorbs moisture in the mouth, whereas the oil provides lubrication that balances this stickiness (Hartel & Hartel, 2008). It contains Protein, fibre, unsaturated fat, and numerous micronutrients, including vitamin E, folate, potassium, magnesium, and zinc (Lukaniuk et al., 2011).

Dark chocolate chips, often called dark compound chips, are crafted from cocoa mass, cocoa butter, and sweeteners. Cocoa also contains minerals like potassium, phosphorus, copper, iron, zinc, and magnesium, which enhance the health benefits of chocolate (Maboodurrahman & Birari, 2015).

The aim of this research work is to formulate and evaluate the quality of banana-based oatmeal energy bars using the response surface method with a randomized mixture design. Sensory evaluation of the energy bar was conducted to determine the acceptability among the formulated samples, and physicochemical properties were statistically analyzed.

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

Materials and Methods

To produce a banana-based oatmeal energy bar, essential raw materials include ripe bananas, peanut butter, oats, and chocolate chips. Fully ripe bananas, i.e., Jahaji (*Dwarf Cavendish*), rolled oats manufactured by Kellogg India Pvt. Ltd, peanut butter of Super Nutri Food, manufactured in India and chocolate chips, morde dark compound chip manufactured by Morde Foods Pvt. Ltd, Bangalore, were brought from the local market of Dharan. Research was conducted in the Department of Food Technology, Dharan Multiple Campus (DMC), Nepal. Chemicals and equipment available in the DMC lab were used.

Experimental design

Randomized mixture design was used to formulate the recipe. Banana and oats were kept constant, and the effect of chocolate chips and peanut variation on the energy bar was studied. The energy bar was made as per the recipe formulation done and coded names A, B, C, D, E, F, G, H, I, J, K, L, M, and Z (control sample) were given to each recipe, as given in Table 1.

Table 1

Formulation of an energy bar

Sample	Oats (g)	Banana (g)	Chocolate chips (g)	Peanut butter (g)
A	25	60	5	10
B	25	60	5	10
C	25	60	5	10
D	25	60	0	15
E	25	60	0	15
F	25	60	0	15
G	25	60	10	5
H	25	60	10	5
I	25	60	3	12
J	25	60	6	9
K	25	60	2	13
L	25	60	9	6
M	25	60	8	7
Z (Control)	25	60	-	-

Preparation of banana-based oatmeal energy bar

The bars were produced following the process outlined by Chitkara et al. (2017) with slight modifications to suit the specific recipe. 14 energy bar samples were created to evaluate the optimal formulation of peanut butter and chocolate chips. Preheat the oven to 175 °C. A fully ripe banana was mashed in a mixer grinder until it was creamy and transferred in to bowl. Peanut butter, rolled oats, and chocolate chips were added and stirred until a thick creamy bar mixture was produced. Transfer the bar mixture into on baking pan, making a thickness of 1.2 cm, and baking 175 °C was done for 30 min. Finally, a banana-based oatmeal energy bar was

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

prepared.

Analytical procedure

Moisture content, crude fat, crude protein, total ash, crude fibre and carbohydrate were determined as described by Ranganna (1986)
Moisture content of the sample was determined using a hot-air oven method.

$$\% \text{ Moisture content} = \frac{\text{Initial wt.} - \text{Final wt.}}{\text{Initial wt.}} \times 100$$

Crude fat content of the samples was determined by the solvent extraction method using a Soxhlet apparatus.

$$\% \text{ Crude fat} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

Crude protein content of the samples was determined indirectly by measuring total nitrogen content by the Kjeldahl method. Factor 6.25 was used to convert the nitrogen content to crude protein. Crude fibre content of the samples was determined by recovering ash-free residue after sequential treatment with 1.25% sulfuric acid and 1.25% sodium hydroxide and by dry ashing.

$$\% \text{ Crude fiber} = \frac{A - B}{C} \times 100$$

Where: A = weight of crucible with dry residue (g)
B = weight of crucible with ash (g);
C = weight of sample (g)

The total ash content of the samples was determined by using an electric muffle furnace.

$$\text{Total ash } (\%, \text{ db}) = \frac{\text{Ash (g)}}{\text{Sample (g)} \times \text{ Dry matter (\%)}} \times 100 \times 100$$

The carbohydrate content of the sample was determined by the difference method. The percentage of carbohydrates (nitrogen-free extract), was obtained from the difference of the subtraction of 100% minus the sum of the percentages of moisture, crude protein, crude fat, crude fibre and ash.

Determination of energy value

The physiological energy value of the energy bar was calculated and described by Nielsen (2017). The total crude protein, crude fat, and carbohydrate were multiplied by the factor value. 1 g of carbohydrate and protein provides 4 kcal of energy, and 1 g of crude fat provides 9 kcal of energy.

$$\text{Energy value} = (\text{carbohydrate} \times 4) + (\text{crude protein} \times 4) + (\text{crude fat} \times 9).$$

Reducing sugar and total sugar were determined by the Lane and Eynon method described by Sadasivam & Manickam (2008).

Calcium content was determined volumetric method described by Ranganna (1986). Briefly, 20 to 100 ml of an aliquot of the ash solution was pipetted out into a 250 ml beaker. 10 ml of saturated ammonium oxalate solution was added, and 2 drops of methyl red indicator were added. The solution was adjusted to a faint pink colour (pH 5.0) by adding dilute ammonia and slightly acidified with acetic acid. It was heated to a boil and allowed to stand for 4 h. It was filtered through the Whatman No. 42 paper. It was washed with water until oxalate-free. The filter paper was broken through the point, and the precipitate was washed into the

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

beaker using hot dilute H_2SO_4. Then it was washed with hot water, and it was titrated hot (70°C to 80°C) with 0.01 N $KMnO_4$ to the permanent pink colour. And at last, filter paper was added to the solution, and titration was completed.

$$\text{Calcium (mg/100g)} = \frac{T \times N \times 20 \times V}{v \times W}$$

Where, T = Titre,
N = Normality of KMnO4 solution,
V = Total volume of the ash solution,
v = Vol. of ash solution taken for estimation,
W = weight of the sample taken for ashing.

Potassium content was determined by the Flame Photometric method described by Ranganna (1986). Briefly, the aliquot of ash solution was diluted so that the solution contained less than 150 ppm potassium. HCl was added to make the concentration of acid as same as the standard solution. Diluted extraction was atomized in a calibrated flame photometer with a wavelength of 768 nm and transmittance which was set at 100% for the standard solution of potassium.

$$\text{Potassium mg/100g} = \frac{\text{ppm found from st. curve} \times \text{volume made up} \times \text{dilution} \times 100}{\text{weight of sample} \times 1000}$$

Antioxidant activity was determined using the DPPH radical scavenging method described by Panico et al. (2009) with slight modifications. The control sample was made by adding 0.28 mL of DPPH solution (0.1 mM, in 80% methanol) to a 10 mL volumetric flask, and then diluting it with 0.944mL methanol to maintain volume. In a similar manner, 0.28 mL of the DPPH solution and 0.28 mL of the test sample were used in the preparation and poured into a 10 mL volumetric flask and 0.944 mL of methanol. The mixture was incubated for 30 min at ambient temperature in the dark. The absorbance of blank infusion and test infusion was determined using a spectrophotometer set at 517 nm. The radical scavenging activity was estimated as a decrease in DPPH absorbance and was calculated using the following equation:

The percentage DPPH radical scavenging activity was calculated as follows:

$$\%\ \text{radical scavenging activity} = \frac{\text{Absorbance control} - \text{Absorbance Sample}}{\text{Absorbance control}} \times 100$$

Textural properties such as width, length, volume and density of banana-based oatmeal energy bar were determined by the method mentioned by Yadav & Bhatnagar (2017).

Length and width

Six energy bars were aligned edge to edge, and their total width was measured with a vernier calliper (0.01 mm accuracy); the average width was calculated by dividing by six. The same method was used to determine the average length by aligning the ends of six bars and taking the mean.

Thickness

Six energy bars were stacked, and their total height was measured in millimetres with a ruler; this was repeated three times to calculate an average thickness, and thickness is expressed in centimetres.

Weight

The weight of energy bars was determined by averaging the measurements of four individual bars using a digital weighing balance.

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

Volume

The volume of energy bars was determined by multiplying length (L), width (W), and thickness (T) using the formula:

$$\text{Volume} = \text{L} \times \text{W} \times \text{T}$$

Where L = average length of energy bars (cm), W = average width of energy bars (cm) and T = average thickness of energy bars (cm).

Density

Density was calculated as the ratio of weight to volume after determining the volume.

$$\text{Density (g/cm}^3) = \frac{\text{Weight (g)}}{\text{Volume (cm}^3)}$$

Sensory analysis

The energy bars prepared were analyzed for sensory evaluation using 9 point hedonic rating scale described by Ranganna (1986). 1 – dislike extremely and 9 – like extremely on sensory attributes like color, smell, taste, flavor, texture and overall acceptability with the help of 10 semi-trained panellists, including faculty and staff of Dharan Multiple Campus, Sunsari, Nepal.

Statistical analysis

The triplicate data from each experiment analysis were subjected to one-way analysis of variance (ANOVA) using IBM SPSS Statistics version 27. Means were compared by the Tukey HSD test at 5% level of significance to determine whether the samples were significantly different from each other. MS Excel 2016 was used for calculations. Results are presented as mean ± standard deviation.

Results and Discussions

The chemical composition of ripe banana, oats, peanut butter and chocolate chips for the preparation of banana-based oats energy bar is given in Table 1.

Table 2

Chemical composition of raw materials

Parameters	Value (%)			
	Banana	Oats	Peanut butter	Chocolate chips
Moisture (wb)	75.85 ± 0.445	12.234 ± 0.105	0.623 ± 0.306	1.513 ± 0.306
Crude protein (%db)	1.104 ± 0.805	13.603 ± 0.050	26.799 ± 0.392	1.346 ± 0.586
Crude fat (%db)	1.068 ± 0.366	6.912 ± 0.100	41.150 ± 0.452	32.3 ± 4.631
Crude fibre (%db)	0.77 ± 0.095	11.656 ± 0.337	3.765 ± 0.506	0.836 ± 0.921
Total ash (% db)	1.86 ± 0.373	1.713 ± 0.007	4.023 ± 0.802	2.065 ± 0.751
Carbohydrate (%db)	91.723 ± 0.125	66.161 ± 0.341	24.263 ± 0.057	63.453 ± 4.698
Energy (kcal, db)	380.54	381.264	574.59	549.89

*Values are the means of three determinations ± standard deviation. Above all the values were expressed in db% except moisture content. The figure in the parentheses indicates standard deviation.

The moisture content, fat and carbohydrate of a fully ripe banana were close to the values reported by Singh et al. (2018). Similarly, protein, crude fibre and total ash content of fully ripe banana were similar to the results reported by Wills et al. (1984). Most proximate compositions varied significantly across ripeness stages and fruit species (Obiageli et al., 2016). The result of the chemical composition of oats obtained in our study was close to the value reported by Syed et al. (2020). The potential cause of changes in the proximate

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

composition of oats is primarily related to the physiological and biochemical processes during germination and growth (Gabrovská et al., 2018). The proximate composition of the peanut butter was found close to the value reported by (Manobanda-Narvaez et al., 2022; Shibli et al., 2019). The major causes that bring differences in the proximate composition of peanut butter include the roasting process, the addition of extraneous ingredients, and the cultivar of peanuts used (Shibli et al., 2019). The results obtained from chocolate chips in this study were similar to the results mentioned in (USDA, 2022).

Sensory analysis of an energy bar

Sensory analysis of the energy bar was performed with the help of ten semi-trained panellists evaluating color, smell, taste, flavor, texture, and overall acceptance. Mean differences of sensory attributes were observed at 5% level of significance.

Panellists preferred the sample G based on its color and smell among other energy bar formulations. Substitution of an increasing amount of chocolate chips and peanut butter has changed the crust color from golden brown to slightly dark brown. The darkening of the product with increased peanut butter and chocolate chips is primarily due to Maillard browning and caramelisation reactions during baking (Eggleston et al., 2018). There was no significant difference among the energy bar formulations. This might be due to the same amount of banana in all samples, so the concentration of the volatile component remains the same across all samples, resulting in a uniform smell. Statistical analysis showed that the partial substitution of peanut butter and chocolate chips had no significant difference ($p>0.05$) in color and smell with the control sample.

Table 3

Sensory evaluation score of banana-based oatmeal energy bar

Sample	Color	Smell	Taste	flavor	Texture	Overall Acceptability
A	7.22 ± 0.72^{a}	6.78 ± 0.20^{a}	6.44 ± 0.72^{abc}	6.22 ± 0.72^{ab}	6.78 ± 0.66^{ab}	7 ± 0.70^{abc}
B	6.78 ± 0.32^{a}	6.44 ± 0.33^{a}	6.56 ± 0.30^{abc}	6.22 ± 0.92^{ab}	6.67 ± 0.91^{ab}	6.44 ± 0.88^{abc}
C	7 ± 0.118^{a}	7 ± 0.11^{a}	7.44 ± 0.28^{abc}	6.78 ± 0.394^{ab}	7.33 ± 0.70^{b}	7.33 ± 0.78^{abc}
D	6.44 ± 0.82^{a}	6.11 ± 0.78^{a}	6 ± 0.66^{ab}	6 ± 0.18^{ab}	6.78 ± 0.83^{ab}	6.44 ± 0.72^{abc}
E	6.78 ± 0.29^{a}	6.11 ± 0.28^{a}	6.33 ± 0.32^{abc}	6 ± 0.16^{ab}	6.89 ± 0.92^{ab}	6.44 ± 0.63^{abc}
F	6.56 ± 0.33^{a}	6.11 ± 0.26^{a}	6.22 ± 0.39^{abc}	6.22 ± 0.56^{ab}	6.22 ± 0.99^{ab}	6.56 ± 0.42^{abc}
G	7.56 ± 0.48^{a}	7.44 ± 0.42^{a}	7.67 ± 0.21^{bc}	7.22 ± 0.09^{ab}	7.44 ± 0.72^{b}	7.67 ± 0.38^{bc}
H	7.33 ± 0.66^{a}	6.89 ± 0.26^{a}	7.67 ± 0.32^{bc}	7.22 ± 0.39^{ab}	7.44 ± 0.52^{b}	7.33 ± 0.67^{abc}
I	6.78 ± 0.83^{a}	6.44 ± 0.52^{a}	6.44 ± 0.52^{abc}	6.56 ± 0.24^{ab}	7 ± 0.866^{ab}	6.56 ± 0.88^{abc}
J	6.89 ± 0.52^{a}	6.56 ± 0.40^{a}	6.78 ± 0.48^{abc}	$6.78\pm.69^{ab}$	6.67 ± 0.82^{ab}	6.89 ± 0.54^{abc}
K	6.67 ± 0.70^{a}	6.44 ± 0.48^{a}	6.11 ± 0.39^{abc}	6 ± 0.92^{ab}	6.22 ± 0.93^{ab}	6.11 ± 0.92^{abc}
L	7.33 ± 0.44^{a}	7.22 ± 0.66^{a}	7.78 ± 0.202^{c}	7.56 ± 0.83^{b}	7.67 ± 0.86^{b}	7.78 ± 0.97^{c}
M	7 ± 0.86^{a}	6.67 ± 0.70^{a}	7 ± 0.68^{abc}	6.67 ± 0.86^{ab}	7.11 ± 0.78^{ab}	7 ± 0.70^{abc}
Z	6.22 ± 0.67^{a}	5.89 ± 0.69^{a}	5.89 ± 0.42^{a}	5.67 ± 0.78^{a}	5.78 ± 0.90^{a}	5.78 ± 0.83^{a}

*Values are the means of three determinations ± standard deviation. Means sharing similar superscripts are not significantly different at 5% significance level.

The mean score was found to be highest for sample L, which was preferred by most of the panellists based on its taste, flavor and texture, and overall acceptability was highest of all other energy bar formulations, which was significantly different ($p<0.05$) from other samples.

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

The sweet taste was contributed by the use of chocolate chips as a sweetening agent. Peanut butter contains good fat and leaves no fat residue layer on the tongue can be the cause of good taste. Chitkara et al. (2017) also found that the increase in peanut butter can enhance the nutty flavor, while more chocolate chips can make the bar sweeter and richer in chocolate taste. The texture of the formulated bar was found to be chewy. The chewiness may be contributed to the fat content of peanut butter and chocolate chips (Tiwari et al., 2017). Statistical analysis showed that the partial substitution of peanut butter and chocolate chips had a significant difference ($p<0.05$) on taste, flavor, texture and overall acceptability. Adamek et al. (2018) reported inclusion of peanut butter and chocolate chips in energy bars contributes to a richer flavor and improved texture. In a sensory evaluation of various energy bar formulations, those containing peanut butter and chocolate chips were noted for their favorable taste, leading to higher overall acceptance.

Determination of the chemical composition of an energy bar

From the statistical analysis of sensory data, samples G and L were not statistically significantly different, so these samples are taken as the best among the other formulated samples. Sample G was made with 25 g oats, 60 g banana, 10 g chocolate chips and 5 g peanut butter, sample L, with 25 g oats, 60 g banana, 9 g chocolate chips and 6 g peanut butter, and lastly, Sample Z (control) with 25 g oats and 60g. Chemical composition of this statistically superior product with the control sample is tabulated in Table 4.

Table 4

Chemical composition of the best product and control

Parameters	Value (%)		
	Sample Z	Sample G	Sample L
Moisture (wb)	50.323 ± 0.208^{a}	43.650 ± 0.324^{b}	43.390^{b} ± 0.122^{b}
Crude protein (db)	6.075± 0.084^{a}	11.082 ± 1.118^{b}	9.604^{b} ± 0.377^{b}
Crude fat (db)	8.783 ± 0.981^{a}	24.409 ± 2.023^{b}	24.620^{b} ± 0.831^{b}
Crude fiber (db)	2.789 ± 0.082^{b}	3.012± 0.190^{ab}	3.213^{a} ± 0.050^{b}
Total ash (db)	1.702 ± 0.169^{a}	2.479 ± 0.366^{b}	2.591^{b} ± 0.210^{b}
Reducing sugar (db)	13.392 ± 1.174^{a}	15.120 ± 0.876^{a}	12.991^{a} ± 0.546^{a}
Total sugar (db)	36.670 ± 0.512^{a}	45.0 ± 0.118^{b}	37.575^{a} ± 0.763^{a}
Potassium (mg/100 g)	297.5 ± 4.44^{a}	355.5 ± 2.053^{b}	361.7^{a} ± 1.63^{c}
Calcium (mg/100 g)	12.52^{b} ± 0.778	15.75^{a} ± 0.53	16.12^{a} ± 0.17
DPPH Inhibition (%)	24.767^{a} ± 3.109	26.833^{a} ± 2.470	28.430^{b} ± 0.306
Carbohydrate (db)	80.651^{b} ± 1.216	59.018^{a} ± 2.368	59.972^{a} ± 0.828
Energy (kcal, db)	425.951	500.081	499.884

*Values are the means of three determinations ± standard deviation. Means sharing a similar superscript are not significantly different at 5% significance level.

The moisture content, crude protein, crude fat, crude fibre, total ash, reducing sugar, total sugar, potassium, calcium, antioxidant, carbohydrate, and energy (kcal) of Samples Z, G

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

and L are shown in Table 4.

The result obtained from this research is close to findings made by Ramírez-Jiménez et al. (2018), who reported 60.97% carbohydrates, 10.71% moisture, 15.31% protein, 5.65% fat, 5.17% total fibre, and 2.20% ash in cereal bar. Ryland *et al.* (2010) evaluated homemade cereal bars and found the following composition: 80.85% carbohydrates, 7.63% moisture, 6.27% protein, 3.44% fibre, 1.13% ash, and 0.68% lipids. Farouk Abdel-salam et al. (2022) reported that the slightly higher fat content in a bar may be important to replenish the energy used during physical activities due to the depletion of energy stores during exercise.

Determination of physical properties of products

The volume and density of the bar increased after the addition of peanut butter and chocolate chips. Length, breadth, thickness, volume, and density of the product were measured and shown in Table 5.

Table 5

Physical parameters of the best product and control sample

Sample	Parameters					
	Length (cm)	Breadth (cm)	Thickness (cm)	Weight (g)	Volume (cm^3)	Density (kg/cm^3)
Control Z	$9.733^{a} \pm 0.40$	$7.067^{b} \pm 0.21$	$1.433^{a} \pm 0.06$	71.95±2.37	$98.566^{a} \pm 5.46$	$0.730^{b} \pm 0.04$
Sample G	$9.200^{a} \pm 0.26$	$6.467^{a} \pm 0.25$	$1.900^{b} \pm 0.10$	89.64±2.66	$113.043^{a} \pm 5.56$	$0.793^{b} \pm 0.04$
Sample L	$9.733^{a} \pm 0.21$	$7.233^{b} \pm 0.12$	$1.933^{b} \pm 0.12$	84.77±2.56	$136.08^{b} \pm 8.67$	$0.623^{a} \pm 0.04$

The values in the table are the arithmetic mean of triplicate samples. The figure in the parentheses indicates the standard deviation. Means sharing similar superscripts are not significantly different at $p<0.05$.

The length, breadth, thickness, volume, and density of the control, G and L samples are presented in Table 4. The thickness of the energy bar ranged from 1.433 to 1.933 cm. The result shows that sample control had the minimum thickness and sample L had the maximum thickness. The volume of energy bars increased linearly with increasing addition of peanut butter and chocolate chips, ranging from 98.552-137.98 cm^3, whereas the density of energy bars ranged from 0.623-0.793 kg/cm^3. Yadav & Bhatnagar (2017) found that the addition of legume increased the volume and density of the bar, i.e., the more legume added, the more the final bar volume.

Conclusions

Addition of peanut butter and chocolate chips affects the physicochemical properties of the energy bar. Energy bars made by incorporating 10 g of chocolate chips and 5 g of peanut butter, and 9 g of chocolate chips and 6 g of peanut butter were found best on the basis of sensory score and physicochemical composition. Further research work could be conducted by making proportion variations of banana and oats in the energy bar formulation. Similar manner, other ingredients like casein, germinated

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SAHAYAATRA (सहयात्रा), Vol. 8 (1), वर्ष ८ (१), May, 2025

gram flour, and beaten rice can also be added instead of peanut butter and chocolate chips and their effect on physicochemical properties could be studied.

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