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Development and Evaluation of Cookies Made with Different Ratios of Red Beans and Chia Seeds

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ABSTRACT

Chia seeds and red kidney beans are rich in fiber and protein content respectively and also help in the prevention of heart disease and maintaining blood glucose levels. **Objectives:** To alternate heavy and fatty snacking with nutritious snacking so it can be consumed by all individuals and provide nutritious benefits. **Methods:** The process was done by making flour of chia seeds and red kidney beans by washing and soaking them in water for 7-8 hours and after sun drying grinding them into the powder form. Then cookies were baked by using different ratios of chia seeds and red kidney beans. After their preparation, physicochemical properties, sensory evaluation and proximate analysis were also done to examine the properties of 3 control groups of cookies. **Results:** The sample cookie B with a ratio (60:40) has overall acceptability for appearance, texture, smell and taste. The Cookie Sample B (60:40) has the highest protein (43.30%) and fiber (24.40). The dry matter and ash% of cookie sample C (70:30) are the highest at (55.37%) and (8.86%). The fat of cookie C (70:30) is the highest (8.86) among all the three samples. The cookie sample B (60:40) has the lowest fat content of about (22.45%). **Conclusions:** It was concluded that cookie sample B (60:40) has overall better nutritional qualities as compared to the other two samples and all the ingredients used in making the recipe of cookies are easily available in local markets.

INTRODUCTION

The baking industry is experiencing significant growth, recognized as a vital sector in food processing, with bread and cookies representing approximately 80% of all bakery products. Cookies are particularly popular due to their convenience, affordability, and extended shelf life, which is attributed to their low moisture content, minimizing the risk of microbial spoilage. As consumer preferences shift toward health-promoting functional foods, there is an increasing demand for products that not only satisfy hunger but also offer nutritional benefits, reducing the reliance on pharmaceuticals [1]. Chia seed flour has emerged as a popular ingredient in various baked goods, enhancing their nutritional profiles. Research indicates that fortifying muffins with chia seeds can increase their protein content by 15% [2]. Cookies enriched with chia seeds are noted for their high fiber, omega-3 fatty acids, and antioxidant content, making them a nutritious alternative to traditional cookies. Nutritional analysis of these cookies demonstrates favourable results in terms of protein, fat, carbohydrates, moisture, and ash content, confirming the feasibility of incorporating nutrient-dense ingredients into commercially available products [3]. Chia seeds, which can be found in various colors brown, white, and black—are not only versatile but also packed with essential nutrients such as calcium, iron, and dietary fiber. Their rich antioxidant profile contributes to reducing

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chronic inflammation and improving overall health. Furthermore, chia seeds can aid in weight management by promoting feelings of fullness and supporting healthy blood sugar levels, making them a valuable addition to weight-reducing beverages [4]. The addition of chia seeds is also beneficial in puddings and breads, enhancing their nutritional attributes and overall quality [5]. While the health benefits of chia seeds are significant, it is essential to consume them in moderation. Excessive intake can lead to gastrointestinal issues, including bloating and diarrhea, especially when combined with certain medications for hypertension and diabetes [6]. This caution is vital for manufacturers as they seek to incorporate chia seeds into their product lines, given their nutritional profile. In addition to chia seeds, the fortification of baked goods with red kidney beans is gaining attention. Rich in fiber and protein, kidney beans serve as an affordable plant-based protein source, often referred to as "poor man's meat." They offer significant health benefits, including improved blood sugar control due to their slow-digesting carbohydrates, which are particularly beneficial for individuals with type 2 diabetes. Red kidney beans also provide essential vitamins and minerals, such as folate, potassium, and iron, along with bioactive compounds that promote health and weight management. Despite their numerous advantages, raw kidney beans can be toxic if not properly cooked, emphasizing the importance of safe food preparation methods [7]. Studies indicate that fortifying cookies with red kidney beans enhances their nutritional content and antioxidant activity while maintaining acceptable sensory qualities [8]. Furthermore, cookies fortified with these legumes exhibit favourable quality parameters, such as spread factor and diameter, while retaining a soft texture and acceptable shelf life of up to 90 days [9]. In conclusion, the integration of nutrient-rich ingredients like chia seeds and red kidney beans into baked goods not only enhances their nutritional value but also meets the growing consumer demand for healthier snack options.

This study aims to develop a recipe to make snacking nutritious and beneficial and to find innovative ways to fortify snacks to improve their nutritional value.

METHODS

This was an experimental study. Development and evaluation of cookies were made with different ratios of red kidney beans and chia seeds. The first group was 50:50, in which half proportion of white flour and the other half proportion of kidney beans and chia seeds flour. The second group was 60:40, in which 60% is flour and 40% is kidney beans and chia seeds flour. The third group was 70:30, in which 70% flour and only 30% is kidney beans and chia seeds flour [10]. A standard recipe for 12 servings of cookies was applied. This recipe is for making 12 servings of the cookies with 50:50 ratios in which half portion is purpose flour and half is chia seed and red kidney beans flour. The recipe can be adjusted according to other ratios 60:40 and 70: 30. 12 cookies from each group were made and then compared (Table 1).

Table 1: Recipe for 12 Servings of Cookies for 50:50 Ratio

Ingredients	Quantity
Brown Sugar	100g
White Sugar	50g
Melted Butter	1 Cup
Egg	1 Medium (Room Temperature)
Vanilla Extract	1 Tea-Spoon
Salt	½ Tea-Spoon
Milk	1¼ Cup
Chia Seed Powder	1 tablespoon (9 Grams)
Chia Seeds	1/2 Tea-Spoon
Red Kidney Beans Powder	9 Table Spoons (70 Grams)
All-Purpose Flour	10 Table Spoons (78 Grams)
Baking Powder	1 Tea-Spoon

The red kidney beans and chia seeds were sifted and washed to remove surface crumbs, weed seeds, and other foreign matter. Raw red beans were soaked overnight and dried in the sun for 7-8 hours. After that, the beans were ground in a grinder to obtain a powdery consistency. The flour was then placed in a zip-lock bag and stored at room temperature. Whereas, chia seeds were soaked for 30 minutes to expand, after which the seeds were dried in normal air for approximately 3-4 hours. The seeds were then ground to a powder in a grinder and stored at room temperature in zip lock bags for preparation of cookies: Sugar, salt and butter were combined in a large bowl and mixed until a smooth texture formed. Eggs and vanilla extract were added and mixed until light lumps formed. Red kidney beans, chia seeds, all-purpose flour, and baking powder were mixed with a spatula. Slowly milk was added until semi-soft dough was formed. Half a teaspoon of chia seeds was folded and the dough was chilled for at least 30 minutes. After that, the oven was preheated at 350°F (180°C). Using an ice cream scoop the batter onto a parchment-lined baking sheet, leaving at least 10cm between the cookies and at least 5cm around the edge of the mold to spread the cookies evenly. Baked for 12-15 minutes or until edges were lightly browned [11]. The physicochemical properties of the cookies were calculated. It includes the weight of the cookies, Thickness of the cookies, diameter of the cookies and spread factor of the dough. The weight of cookies is measured by weight scale in gram units. So, for measuring the weight of cookies first of all we will put the scale readings on zero value. Then, place the China dish on it for weighing and note down the weight. After this, press the zero buttons and again place the dish on the weight scale by putting the cookies' sample in it and then note down the readings of weight. We

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measured the thickness of cookies in centimetres by using a Vernier caliper. It has two main scales that are named as zero scale and the Vernier scale. The zeroes of these scales concurred with each other when their jaws were going to meet each other. For measuring the thickness of cookies, first of all, by using a magnifying glass, we will ensure that the zeroes of Vernier and main scale are ideally concurring with each other. Then, we will write down the number of divisions of these scales to avoid errors. By slightly loosening the screw, we will release the moveable jaw. Without any pressure; slightly move it to grasp the cookies between the jaws of the Vernier caliper. Then, perpendicularly align it to the thickness of the cookies. Now at this point, we will slightly tighten the screw and point out the position of the zeroes of the Vernier scale against the zero scale. Which normally will not concur with the divisions of the main scale. After this, write down the readings of the Vernier scale and main scale divisions' coincidence; from left to right. Then, jot down the values that are obtained from the least count of Vernier caliper and add them to the readings of the main scale. Now, in a tabular column, we will record the observations of proper reading (If required, then apply zero correction). Now, find the arithmetic mean of the thickness of cookies. Diameter is also measured by using a Vernier caliper, for measuring the diameter of cookies, first of all, by using a magnifying glass, we will ensure that the zeroes of Vernier and the main scale are ideally concurring each other. Then, we will write down the number of divisions of these scales to avoid error [12]. By slightly loosening the screw, we will release the moveable jaw. Without any pressure; slightly move it to grasp the cookies between the jaws of the Vernier caliper. Then, perpendicularly align it to the diameter of the cookies. Now at this point, we will slightly tighten the screw and point out the position of the zeroes of the Vernier scale against the zero scale. Which normally will not concur with the divisions of the main scale. After this, write down the readings of the Vernier scale and main scale divisions' coincidence; from left to right. Then, jot down the values that are obtained from the least count of Vernier caliper and add them to the readings of the main scale. Now, in a tabular column, we will record the observations of proper reading (If required, then apply zero correction). Now, find the arithmetic mean of the diameter of cookies. The spread factor is measured by dividing the values of diameter by the thickness of the cookies. The spread factor is defined as the characteristics or acceptability of cookies. If cookies have the highest spread factor ratio, then they will be considered more desirable or profitable. Spread factor=diameter of cookies/thickness of cookies. Sensory analysis was accomplished by the 15 members of the expert panel from the School of Health Sciences. The sensory characteristics like appearance, taste, smell and texture were analysed of A, B, and C samples of cookies and graded according to the Hedonic scale [13]. The hedonic scale is used to analyze food acceptability or food preferences; to like extremely, like very much, neither like nor dislike or dislike extremely [14]. The main nutritional components of these cookies; protein, fat, moisture or ash content are estimated by proximate analysis. Proximate analysis was held at labs of the University of Veterinary and Animal Sciences [15]. The raw material used defines the dry matter content of any substance [16]. For the estimation of mineral or ash content, first of all, we weighed an empty china dish; with having flat bottom. Then we put the sample in this dish and measured the weight of the sample whose values would be equal to W1. Place it in an oven at 105°C for at least 4 hours. After the desired temperature; remove the China dish let it cool in a desiccator and again weigh it. Again, place the dish in an oven for 4 hours and weigh it. We will repeat this process until constant reading is obtained. Then, after drying we will estimate the sample of cookies along with a dish that is equal to w2. Moisture%=(weight of fresh sample-weight of the sample after drying × 100)/weight of the sample. The moisture content of these cookies was estimated by charring process; by placing the crucible in a muffle furnace at 650°C for 4 hours until white ash is obtained. Then execute the crucible after ashing that contains weight gain and ash. Ash% is calculated by: Ash%=(weight of ash+ crucible weight gain - the weight of crucible × 100)/weight of fresh sample. Protein content is measured by the Kjeldahl method, which consists of three steps; digestion, distillation and titration [17]. In this method, firstly we grab a dry and clean digestion flask then take one to five food samples of 5 grams of digestion mixture. Then put 30ml of concentrated solution of H2SO4 in a digestion flask. Now, put the flask in a fume hood and increase the temperature for 2 to 3 hours until the digestion mixture turns into copper sulphate or sea light green colour and acts as a catalyst. After this, let the flask cool down and place it with distilled water, in a 250ml volumetric flask. Now grab the diluted sample of 10ml and pour 10ml of 40% sodium hydroxide into it. Then transfer the flask to the tube of the distillation apparatus through the fitting tube. Place the beaker in the distillation apparatus and add 10 ml of boric acid solution of 4% with 2 to 3 drops of indicator in a separate beaker. During this process, the colour of the boric acid solution will turn from pink to yellow-golden. The volume of acid used for titration would be calculated by noting down the titrate distillate against H2SO4 or 0.1 NH4Cl till the light pink colour is obtained. Hence, firstly we determined the total nitrogen content of cookies by using this equation: Nitrogen%= (volume of H2SO4 used - normality of H2SO4 – 0.0014*volume of dilution*100)/weight of sample × 10. Then, use the value of N% to find crude protein by this formula:Crude protein= $\%N^2$*6.25.Lipid content is estimated by the Soxhlet extraction method. In which; a TLC plate is mainly used to

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estimate different types of lipids in cookies. In this procedure, first of all, make a thimble by using filter paper and weighing (W1) it. In thimble paper, the accurate weight represents the dry sample (5g). Now for extraction of lipids, the thimble has to be placed in the Soxhlet apparatus. Then by using petroleum ether, extract fat from food for at least 8 to 12 cycles (Siphon off). Turn the heat off after complete extraction and remove the sample by using filter paper. At 70-100°C, evaporate petroleum ether till constant weight is achieved. After this, let it cool to room temperature. Then weigh again by using filter paper and samples after extraction. Fat content is also calculated by using this equation: Lipid%= (weight of thimble with sample before fat extraction – the weight of thimble fat – free sample after extraction × 100)/weight of the sample. Total fiber content is estimated by adding 95% ethanol solution to precipitate fiber then this solution is filtered and fiber is collected, dried and weighed. In the process of determining fiber content in food about 2g of food sample is required which should be dry, representative and defatted and placed in a digestion flask then add 200ml boiling 1.25% sulphuric acid in it. In the next step, attach the flask with the condenser and boil it at least for 30 minutes. By using muslin cloth or filter paper, filter the content of the flask in a fluted funnel. Then wash the remaining residue by using distilled water until washings are free from acid. Then repeat the process by transferring it to the digestion flask add 1.25 sodium hydroxide (200ml and connect the flask to the condenser. Boil it for half an hour. Then filter this hot material by using a muslin cloth wash it completely with boiling water and collect the remaining (residue) in a China dish. After washing the acid, alkali and dry sample at 70°C in the oven to constant weight. Cool it at room temperature and weigh it (W1). Then place it in a weight crucible(W2). Place the ignited sample in a muffle furnace at 625◦C for about 4 hours and then weigh again (W3). At last, record weight loss and calculate the percentage of crude fiber. Moreover, it is also calculated by this equation: Fiber%= (weight of crucible with sample before ashing – the weight of crucible with ash after drying × 100)/weight of the sample. The three samples of cookies A, B, and C were compared according to the sensory properties by using one-way ANOVA on SPSS. It is used to check whether there is a significant difference between all the cookie groups. Multiple comparison tests (Post Hoc test) will be performed for each of the possible groups within cookies if there are significant differences between all groups.

RESULTS

The three samples were developed from the recipe mentioned in the methodology portion. Each sample has the defined ratios of both chia seeds and red kidney bean flour as mentioned above. According to the physicochemical properties, cookie C with a ratio (of 70:30) has the highest weight of about 62g. In the same ratio cookie C has the largest diameter of about 6.7cm and the greatest thickness which is 6.2cm. The spread factor of cookie C with ratio (70:30) is also the largest (Table 2).

Table 2: Physicochemical Properties of the 3 Different Variations of Cookie Dough

Variables	Dough A 50:50	Dough B 60:40	Dough C 70:30
Weight (Grams)	20g	37g	62g
Diameter	5.8cm	6.2cm	6.7cm
Thickness	5.2cm	5.9cm	6.2cm
Spread Factor	1.115	1.0505	1.0806

By using a hedonic scale, the sensory attributes of the cookies were analyzed. It includes appearance. Taste, smell and texture. The results of the sensory evaluation were described through pie charts given below of 3 ratios of cookies. The figures below show that in appearance. The cookie sample A (50:50) and cookie sample B (60:40) are almost similar and liked extremely by almost 26.67% of the panel. 40% of the panel liked extremely the taste of cookie sample B (60:40). The smell of cookie B (60:40) and cookie sample C (70:30) was almost similar and each was liked by 20% of the expert panel. The Texture of cookie sample B (60:40) was highly acceptable by the panel. Hence the bar chart given shows the overall acceptability of the cookie sample B (60:40). It shows that the sample Cookie B has overall acceptability for appearance, texture, smell and taste (Figure 1).

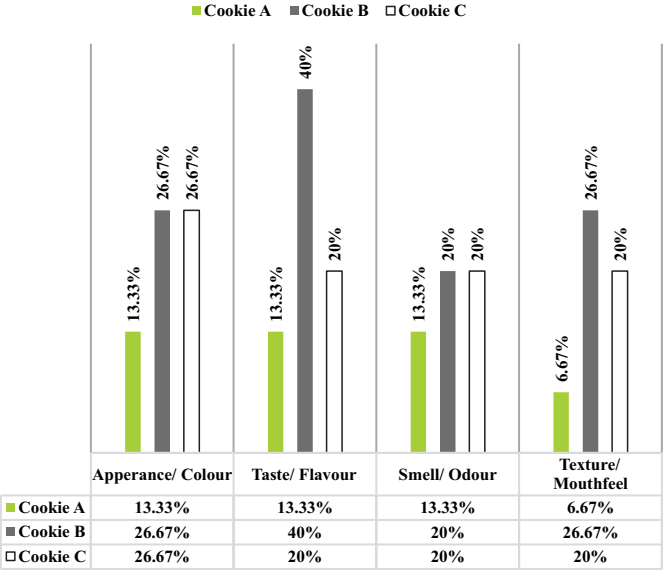

Figure 1: 3 Ratios of Cookies Sensory Analysis

After the graphical representation of the sensory attributes of cookies, the statistical analysis was performed. On SPSS, One-Way ANOVA shows p-value (0.007) is less than α (0.05) which means that there is a significant difference between all the cookie groups A, B, C (Table 3).

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Table 3: One-Way ANOVA

No of People	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.667	2	6.333	9.120	0.007
Within Groups	6.250	9	0.694	-	-
Total	18.917	11	-	-	-

To check if there is a significant difference between groups A-B, A-C and B-C, a multiple comparison test (LSD) was performed. The p-value (0.002) for group A is less than α (0.05) which shows that there is a significant difference between cookies A and B. The p-value (0.031) for cookie A-C is also less than α (0.05) which shows that there is significant difference between cookie A and C. The p-value (0.124) for cookie B-C is greater than α (0.05) which shows that there is no difference between cookie B and C. So, the overall results of the statistical analysis show that Cookie B is extremely liked for all the sensory attributes as compared to Cookie A and Cookie C (Table 4).

Table 4: Post Hoc Test

Cookie Type (I)	Cookie Type (J)	Mean Differences (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-2.50000*	0.58926	0.002	-3.8330	-1.1670
	C	-1.50000*	0.58926	0.031	-2.8330	-0.1670
B	A	2.50000*	0.58926	0.002	1.1670	3.8330
	C	1.00000*	0.58926	0.124	-0.3330	2.3330
C	A	1.50000*	0.58926	0.031	1.1670	2.8330
	B	-1.00000*	0.58926	0.124	-2.3330	0.3330

Dependent Variables: no of people LSD

The cookie sample C (70:30) has the highest mean (7.93 ± 0.96) for appearance. The mean of cookie sample B (60:40) is the highest (7.7 ± 1.22) for taste attribute. The cookie sample C has the greatest mean (7.66 ± 1.11) for the attribute smell and (7.53 ± 1.18) for texture (Table 5).

Table 5: Statistical Analysis

Samples	Appearance	Taste	Smell	Texture
Cookie A 50:50	7.53 ± 0.92	7.60 ± 0.91	7.60 ± 0.91	7.33 ± 0.98
Cookie B 60:40	7.80 ± 0.86	7.73 ± 1.22	7.56 ± 1.16	7.40 ± 1.28
Cookie C 70:30	7.93 ± 0.96	7.53 ± 1.30	7.77 ± 1.11	7.53 ± 1.28
Total	7.76 ± 0.91	7.62 ± 1.13	7.58 ± 1.01	7.42 ± 1.10

After the physicochemical and sensory properties of the three cookie samples proximate analysis was done to analyze the nutritional content of the cookies. Proximate analysis includes dry matter%, crude protein%, crude fiber%, fat%, ash % and NFE% [18]. Cookie sample B (60:40) has the highest protein (43.30%) and fiber (24.40%) content as compared to cookie samples A and C. The Dry matter and ash of cookie sample C (70:30) are the highest at (55.37%) and (8.86%). The fat of cookie C (70:30) is the highest (8.86) among all the three samples. The cookie sample B (60:40) has the lowest fat content of about (22.45%) (Table 6).

Table 6: Proximate Analysis

Type of Tests	Sample A	Sample B	Sample C
Dry Matter (%)	37.68	45.15	55.37
Crude Protein (%)	40.70	43.30	39.60
Crude Fiber (%)	22.85	24.40	19.35
Fat (%)	23.05	22.45	29.0
Ash (%)	7.50	7.16	8.86
NFE (%)	5.90	2.69	3.19

DISCUSSION

Thus, the results show that cookie sample B (60:40) has overall better nutritional and sensory qualities as compared to the other two samples. This research was based on the development and evaluation of cookies made with red kidney beans and chia seed flour. Three different ratios were taken as 70:30, 50:50 and 60:40 [19]. According to past research, cookies were developed either using three ratios of only chia seed flour or three ratios of only red kidney bean flour. However, this research includes the use of both red kidney bean flour and chia seed flour in one cookie with three different ratios. This research proves that cookies made with 60:40 ratios have shown more appropriate results for nutrition. Nutritional evaluation was done by proximate analysis which is the standard official method and applied internationally [20]. According to previous research on cookies made with chia seeds flour, it was stated that the cookies with the lowest ratios that is 15% and 10% out of all the controls were acceptable both nutritionally and in texture, flavor etc. And researches on cookies, made with red kidney beans flour, it was stated that the cookies with 15% and 10% ratios were acceptable. But in this research, the cookies with Ratios of 40% of red kidney beans and chia seeds flour were acceptable both nutritionally and in texture, flavor etc. According to previous research, during sensory analysis, cookies made with 20% ratios of red kidney beans were not acceptable due to their texture and color appearance. Cookies of sample C, with the lowest ratios of red kidney beans or chia seeds flour, are 15% 15%and 10%were acceptable during sensory analysis. But in this research, the taste of all three samples; A, B, and C, were acceptable based on taste and odor; during proximate analysis and sensory analysis. But

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based on the texture, color, appearance and as well as taste and smell of cookies, sample B, with 60:40 ratios of red kidney beans and chia seeds flour was more acceptable. In the past research, the physical properties of dough with different ratios of 0%, 5%, 10%, and 15% were also measured. In which, the thickness of cookies was increased while the spread factor of cookies was increased according to the above ratios. But in this research, the thickness, and diameter of the 60:40 ratios were less than 50:50 ratios of cookies. On the other hand, the spread factor having a 60:40 ratios are more than the 50:50 ratios of cookies made with red kidney beans and chia seeds flour. A past study also showed that 90% wheat flour with 10% red kidney bean flour has the overall acceptability [21]. A study showed that the addition of 20% chia seeds in cookies has overall acceptability [22]. Moreover, according to former studies, cookies with ratios of 15% of red kidney beans have lower fiber content and higher fat content. But, in this research, cookies made with 60:40 ratios of red kidney beans and chia seeds flour have higher protein and fiber content as well as lower fat content. So, this research proves that the sample B of these cookies have more nutrient content and is acceptable as healthy snacking. Besides that, all the ingredients used in making the recipe of cookies are easily available in local markets. And these cookies are protein and fiber-rich due to red kidney beans and chia seeds flour. Moreover, there is still a need to research all the physicochemical properties, analysis of moisture content, shelf life and stability of the cookies.

CONCLUSIONS

It was concluded that nutritious cookies were developed using chia seeds and red kidney beans flour as chia seeds are high in fiber, which can help to lower blood pressure whereas red kidney serve as a rich source of plant-based protein and helpful in maintaining blood glucose levels and promote colon health as well. In combination both ingredients also play a role in disease prevention. Its evaluation includes physiochemical properties, sensory analysis and proximate analysis were completed on the three samples that were extracted from the stock sample. Under the evaluation sensory analysis and proximate analysis were observed. Based on sensory analysis which was done by using a hedonic scale group B was mostly liked as it is high in protein and low in fat content according to proximate analysis and group C was also acceptable. Further, there is still a need for such studies to be conducted to make snacking healthier.

Authors Contribution

Conceptualization: IS
Methodology: IS, SND, AN, MI, FB, ISA, HK
Formal analysis: IS, SND
Writing review and editing: IS
All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

All the authors declare no conflict of interest.

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