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Impact of Date Powder, Sacha Inchi Oil, and Moringa Powder in a Novel Cognitive-Enhancing Health Bar: An Evaluation of Physicochemical Properties and Functional Benefits

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Abstract

Recent trends show a growing preference for healthy snacks in diets, particularly among health-conscious consumers, with snack bars gaining popularity among youth. This study aimed to develop and analyse a nutritious health bar to enhance cognitive performance. The health bar's formulation was created using design expert software. Comprehensive testing included proximate analysis, fatty acid profiling, and vitamin, mineral, and antioxidant evaluations, complemented by texture and colour assessments. Findings reveal these bars to be nutritionally rich, featuring excellent physical characteristics. They are notably abundant in essential fats (omega-3 and omega-6), vitamins, and minerals. The bars' high essential fat content, varied vitamin and mineral composition, and strong antioxidant properties align with the Recommended Nutrient Intakes (RNI) for Malaysian children and adolescents. This composition suggests that these health bars could effectively boost cognitive performance in this group.

Keywords:
Physicochemical properties; *Halalan toyyiban*; Health bar; Cognitive function; Design expert; Recommended nutrient intakes (RNI); Adolescents

1. Introduction

Recent shifts in consumer behaviour indicate a gradual movement towards more intelligent and health-conscious eating and snacking patterns. Emphasis on maintaining overall health and wellness is not just limited to exercise and fitness; it significantly encompasses the practice of balanced dietary habits. This shift is partly spurred by health promotion campaigns and the implementation of nutritional guidelines in hospitals and public settings, notably increasing consumer health awareness (Curtain & Grafenauer, 2019). Consequently, healthier snacking options have been integrated into everyday diets, providing consumers with an extensive array of choices that align with their perception of healthy eating. Among these options, snack bars have emerged as popular, especially among children and adolescents. Recent trends have seen snack bars increasingly occupy a prominent place in grocery store aisles (Andrew, 2018; Mohd Noor, Hazahari & Shahidan, 2022). Their appeal spans a diverse consumer base, ranging from athletes to the working population, owing to their convenience, immediate energy boost, nutrient content, and satiety.

Integrating functional ingredients into the bars has significantly added value to them. Functional ingredients are bioactive compounds that can manufacture food products to give consumers extra health benefits beyond basic nutrition (Syed, Akram & Shukat, 2019). In response to this demand, manufacturers are fortifying snack bars with functional ingredients that provide essential nutrients like vitamins, minerals, antioxidants, and fibre, addressing the growing need for genuinely 'healthy bars' (Amerikanou *et al.*, 2023; Hess, Rao & Slavin, 2017). This nutritional enhancement promises a sustainable, global market appeal. The evolving consumer expectation towards low-sodium, low-calorie, and low-sugar products challenges manufacturers to innovate while maintaining the bars' original taste and appeal. Such innovation holds the potential to capture a wider consumer segment, particularly young people, who significantly drive global snack bar sales (Curtain & Grafenauer, 2019).

Furthermore, the link between a balanced diet and cognitive performance, especially in children and adolescents, is becoming increasingly evident. Studies show that adequate and nutritious food intake optimises brain functions like focus, comprehension, and application in learning contexts (Salam *et al.*, 2019; Correa-Burrows *et al.*, 2016). In Islamic dietary practices, the concept of *halalan toyyiban* — promoting balanced nutrition for both the body and the soul — is integral (Abd Razak, Ramli, and Jamaludin, 2019). Foods that are both halal and *toyyib* (wholesome) are believed to be beneficial for brain health due to their high nutrient content (Wahju Dyah *et al.*, 2018).

Given this backdrop, this study was initiated with dual objectives: first, to create a *halalan toyyiban* health bar tailored to enhance cognitive performance in children and adolescents as a part of their daily snack intake; second, to analyse its physicochemical properties. This involved conducting comprehensive proximate, vitamin, and mineral analyses, assessing antioxidant activity and determining the bars' texture and colour to underline their nutritional and sensory qualities. The remarkable results obtained from the first two objectives will be used for a later stage of this study by conducting an acceptance test of the health bar and investigating the cognitive performance of school children and adolescents before and after the health bar intervention in the diet while testing the suggested theory in this paper.

2. Materials and methods

2.1 Materials

Several components were included in the health bar formulation, notably the functional ingredients. Date powder, Sacha inchi *(Plukenetia volubilis)* oil, and Moringa (*Moringa oleifera)* powder were obtained from local manufacturers in Selangor. The primary structure of the health bar, comprising bubble rice, pumpkin seeds, and oats, was acquired from a manufacturer in Klang, Selangor. Additionally, Beryl's dark chocolate compound and sugar alcohols (maltitol and isomalt) were utilised as coatings for the health bar.

2.2 Methods

2.2.1 Development of a health bar recipe

Optimisation of the functional ingredients (Date powder, Sacha inchi *(Plukenetia volubilis)* oil, and Moringa (*Moringa oleifera)* powder) was conducted based on the simplex lattice design (Ying *et al.*, 2018), capping at a maximum of 25% for the 25.00 g health bar recipe. The quantities of other ingredients, including dark chocolate compound, maltitol, isomalt, bubble rice, oats, and pumpkin seeds, were kept constant throughout the study. A previous study had established that the upper limits for date powder, Sacha inchi *(Plukenetia volubilis)* oil, and Moringa *(Moringa oleifera)* powder were 12.5%, 10.0%, and 7.5%, respectively, while their lower limits were set at 7.5%, 5.0%, and 2.5%, respectively (Sarifudin *et al.*, 2020). These limits were inputted into Stat Ease Design Expert Version 12, yielding 14 different health bar formulas.

2.2.2 Assembling the health bar

All ingredients were measured according to the recipe as the initial step in preparing the health bar. The pumpkin seeds and oats were then toasted in an oven at 160°C for about 5 minutes (Ho *et al.*, 2016), followed by mixing with bubble rice and Sacha inchi *(Plukenetia volubilis)* oil. Subsequently, the sugar alcohols (maltitol and isomalt) along with date powder were melted at 150°C (Hadjikinova & Marudova, 2016) and then combined with the main components of the health bar (bubble rice, pumpkin seeds, and oats). The dark chocolate compound was melted using a double boiler method and then mixed with Moringa *(Moringa oleifera)* powder, ensuring thorough stirring to prevent clumping. The health bar was then formed by pressing the mixture into a mould measuring 20.0 cm x 20.0 cm x 3.0 cm. The melted dark chocolate compound was evenly drizzled over the health bar and then stored in the refrigerator before analyses.

2.2.3 Composition assessment with proximate analysis

The proximate composition of the 14 health bars, including moisture, ash, protein, fat, fibre, carbohydrate, and energy content, was determined following the AOAC methods 18th ed. 2005, 984.25, 923.03, 981.10, 991.36, 962.09, respectively. These measurements were conducted in triplicate.

2.2.3.1 Moisture content

The moisture content of all health bar samples (14 formulations) was analysed using a moisture analyser (METTLER TOLEDO, United States). Around 2.0 g of the health bar from each recipe was weighed using a weighing scale (Sartorius, Germany) and individually placed in the moisture analyser. The samples were run in the moisture analyser until the optimum moisture content was reached. The final moisture content readings for each sample were recorded in the logbook.

2.2.3.2 Ash content

The total ash content of all health bar samples was determined following AOAC (1990), Method 923.03. The percentage of crude ash was calculated using the following equation:

$$Crude\ ash\ (dry\ basis)\ (\%) = (W1 \div W2) \times 100$$

W1 is the weight after ashing, and W2 is the weight before.

2.2.3.3 Protein content

All health bar samples' protein and nitrogen content were analysed using the Kjeldahl Method (AACCI, 1995), Method 46-11.02. The samples underwent processes of digestion, distillation, and titration. Upon completion of titration, the instrument displayed the final percentage of protein and nitrogen, which was recorded in the logbook. The percentage of crude protein was expressed from the total nitrogen percentage, multiplied by a factor of 6.25 – the nitrogen-protein conversion factor for grain samples. The measurement of crude protein was calculated using the following equation:

$$Crude\ protein\ (\%) = Nitrogen\ (\%)\ in\ sample \times 6.25$$

2.2.3.4 Fat content

The fat content of all health bar samples was analysed using the Automatic Soxhlet extraction method (Gerhardt Soxtherm® extractor, Germany). Approximately 2.0 g of samples from each recipe were weighed on filter papers. Each filter paper containing the sample was folded and placed into a pre-dried extraction thimble, topped lightly with glass wool. Then, the thimble was positioned into the extraction beaker containing three boiling stones and filled with 130 mL of petroleum ether. The instrument was programmed according to Gerhardt's manual. Finally, the extracted residue was dried overnight in an oven at 105°C. The percentage of fat content was calculated using the following equation:

$$Fat\,(\%) = [(W1 - W2) \div W0] \times 100$$

W1 is the total weight of the extraction beaker with boiling stones and extracted fat, W2 is the total weight of the extraction beaker and boiling stones, and W0 is the weight of a healthy bar sample.

2.2.3.5 Crude fibre content

The crude fibre content of all healthy bar samples will be determined according to the AOAC (1990) Method. The crude fibre will be determined by the digestion of samples with sulphuric acid. Moreover, sodium hydroxide is on a hot plate (Favorit, Malaysia), as Adamu, Ajayi and Oyetunde (2016) claimed. The crude fibre content will be calculated using the following equation:

$$Crude\,fibre\,(\%) = [(C - A) - (D - E)]\,/\,B \times 100$$

C is the weight of the crucible and dried fibre bag after digestion, A is the weight of the fibre bag, D is the weight of the crucible and ash, E is a blank value for the empty fibre bag, and B is the weight of the healthy bar sample.

2.2.3.6 Carbohydrate content

The carbohydrate content of all health bar samples was determined using the following equation:

$$Carbohydrate\,(\%) = 100 - [Moisture\,(\%) + Ash\,(\%) + Protein\,(\%) + Fat\,(\%)]$$

2.2.4 Fatty acid composition

Referring to the proximate analysis results, only two health bar formulations were selected for further analysis. The fatty acid profiling of these selected formulations was conducted using the AOAC method 20th edition 2016, 996.06. The measurements were carried out in triplicate.

2.2.5 Evaluation of mineral, vitamin and antioxidant levels

The mineral content (magnesium) of the selected health bar formulations was determined using the Atomic Absorption Spectroscopy (AAS) Method No: STP/Chem/A13-AAS. In addition, the vitamin E (alpha-tocopherol) content in these formulations was determined using the High-Performance Liquid Chromatography (HPLC) Method No: STP/Chem/A11-HPLC. Antioxidant activity was evaluated by monitoring the inhibition (%) of the compound 2,2-diphenyl-1-picrylhydrazyl (DPPH). These measurements were conducted in triplicate.

2.2.6 Assessment of texture and colour

Two of the selected health bar formulations were tested for hardness using Texture Analyzer TA-XT Plus (Stable Micro System, London), referring to the method as previously described (Puangjinda, Matan & Nisoa, 2016). To evaluate the colour of the selected health bar, the Hunter Lab Colorimeter (LabScan XE Spectrophotometer, Hong Kong) was used as described in the previous study (Prazeres *et al.*, 2017). The measurement was carried out in triplicate.

2.2.7 Quantitative data analysis

The statistical analyses for this study were conducted using the SPSS software, version 20.0 from IBM. Utilising analysis of variance (ANOVA), relationships among various variables were tested. Measurements for this study were taken thrice, and the significance of differences in the mean values of the samples was determined, with a significance level set at $p < 0.05$.

3. Results and disussion

3.1 Fundamental nutrient composition of health bar

The nutrient composition of 14 different health bar formulations was determined using proximate analysis, focusing on moisture, ash, protein, fat, fibre, carbohydrate, and energy content. The data depicted in Table 1. This table illustrate the nutrient levels per 100 g servings of these health bars.

For moisture content, our health bars showed a range of 5.15 to 7.89 g per 100 g servings, a markedly lower range than date paste snack bars (15.73% - 26.25%), as Parn *et al.* (2015) reported. This reduction is attributed to our use of powdered ingredients over the paste, a shift that Cuq *et al.* (2013) noted typically leads to decreased moisture and, consequently, longer shelf lives.

In contrast, the ash content in our health bars was notably higher, ranging from 2.17 g to 2.85 g per 100 g servings, compared to the 1.88% - 1.93% in date paste bars. Nevertheless, our bars showed lower ash content than oat-date paste bars (1.4% - 4.5%), as Munir *et al.* (2018) reported. Such results suggest our bars may be rich in certain micronutrients, especially magnesium and vitamin E, as inferred from their ingredients like dates, Moringa *(Moringa oleifera)*, and pumpkin seeds (Syed, Akram & Shukat, 2019; Gopalakrishnan, Doriya & Kumar, 2016). Besides, these studies found that magnesium and vitamin E are pivotal in enhancing cognitive performance since they transport energy to brain cells.

Protein levels in our bars ranged between 9.33 g and 10.96 g per 100 g servings. These figures surpass those in prior studies (Ho *et al.*, 2016; Parn *et al.*, 2015) and nearly meet the European Consumer Health and Consumers Directorate-General's (2012) minimum guideline of 10 g of protein in health bars. Our ingredient selection, including protein-rich Moringa *(Moringa oleifera)* powder and pumpkin seed, led to several formulations achieving the desired protein content. Furthermore, these bars potentially provide 21% to 26% of the Malaysian Recommended Nutrient Intake (RNI) protein in children and adolescents.

Fat content was another area where our bars excelled, showing higher values (15.06 g - 22.76 g per 100 g servings) than previous studies by Munir *et al.* (2018) and Parn *et al.* (2015). The bars incorporate omega-3 and omega-6, high in essential fatty acids from sources like Sacha inchi *(Plukenetia volubilis)* oil and Moringa *(Moringa oleifera)* powder. Ya-Nin & Phakkharawat (2017) research indicated that such inclusion could enhance cognitive functions in children and adolescents. By Malaysian health standards, these bars could contribute around 25.0% to 30.8% of the total recommended fat intake for the youth.

Although the fibre content was relatively modest (1.38 g - 3.47 g per 100 g servings), it aligns with the findings by Saini *et al.* (2021) and Javed *et al.* (2020). Meeting the European Union's

Table 1. Nutrient composition of the health bar

Formulation	Test Parameter / Nutrition facts (per 100 g)						
	Moisture (g)	Ash (g)	Protein (g)	Fat (g)	Crude fibre (g)	Carbohydrate (g)	Energy (kcal)
1	6.09 ± 0.09^{b}	2.76 ± 0.03^{b}	9.38 ± 0.45^{c}	17.80 ± 0.22^{c}	2.30 ± 0.29^{b}	63.97^{a}	453.61^{b}
2	7.10 ± 0.27^{a}	2.49 ± 0.03^{b}	9.67 ± 0.43^{c}	18.17 ± 0.73^{c}	3.47 ± 0.24^{a}	62.56^{a}	452.45^{b}
3	7.69 ± 0.08^{a}	2.37 ± 0.03^{b}	9.80 ± 0.09^{c}	19.68 ± 0.29^{b}	2.34 ± 0.09^{b}	60.48^{a}	458.21^{b}
4	7.87 ± 1.51^{a}	2.43 ± 0.02^{b}	9.51 ± 0.13^{c}	19.59 ± 0.49^{b}	2.75 ± 0.04^{b}	60.60^{a}	456.73^{b}
5	6.80 ± 0.16^{b}	2.49 ± 0.06^{b}	9.41 ± 0.06^{c}	16.83 ± 0.16^{c}	1.67 ± 0.35^{c}	64.47^{a}	446.98^{b}
6	6.41 ± 0.11^{b}	2.85 ± 0.07^{b}	9.82 ± 0.51^{c}	15.06 ± 0.23^{c}	2.55 ± 0.25^{b}	65.87^{a}	438.25^{b}
7	6.02 g ± 0.07^{b}	2.57 ± 0.01^{b}	10.03 ± 0.11^{c}	17.86 ± 0.31^{c}	1.49 ± 0.29^{c}	63.52^{a}	454.92^{b}
8	5.97 ± 0.51^{c}	2.44 ± 0.05^{b}	9.43 ± 0.06^{c}	18.73 ± 0.90^{c}	1.38 ± 0.11^{c}	63.43^{a}	460.01^{b}
9	5.23 ± 0.15^{c}	2.36 ± 0.06^{b}	9.33 ± 0.08^{c}	21.01 ± 0.95^{b}	2.17 ± 0.32^{b}	62.07^{a}	474.67^{b}
10	5.15 ± 0.12^{c}	2.35 ± 0.011^{b}	10.38 ± 0.18^{b}	20.22 ± 0.27^{b}	2.14 ± 0.19^{b}	61.90^{a}	471.10^{b}
11	5.25 ± 0.12^{c}	2.31 ± 0.007^{b}	10.31 ± 0.08^{b}	22.76 ± 0.13^{b}	1.92 ± 0.04^{c}	59.37^{a}	483.58^{b}
12	5.81 ± 0.09^{c}	2.33 ± 0.009^{b}	10.86 ± 0.16^{a}	19.88 ± 0.64^{b}	3.36 ± 0.22^{a}	61.12^{a}	486.83^{b}
13	5.43 ± 0.35^{c}	2.17 ± 0.006^{b}	10.96 ± 0.04^{a}	20.91 ± 0.56^{b}	2.42 ± 0.43^{b}	60.53^{a}	474.13^{b}
14	5.62 ± 0.03^{c}	2.29 ± 0.005^{b}	10.51 ± 0.09^{a}	21.31 ± 0.43^{b}	3.34 ± 0.23^{a}	60.28^{a}	474.92^{b}

Values are means ± SD. Values with the same letters within the same column are not significantly different ($p < 0.05$).

(EU) definition of a source of fibre, the bars promise a longer satiety duration, a claim supported by Ho *et al.* (2016).

Lastly, our health bars could provide a significant percentage of the daily energy requirement for active adolescents and children, between 16.60% and 22.86%. Carbohydrate levels, deduced through basic calculations, ranged from 59.37% to 65.87%, akin to the findings of Parn *et al.* (2015).

3.2 Polyunsaturated fatty acid composition of health bar

Following the proximate analysis results presented in Table 1, we chose two health bar formulations, Formulation 12 and Formulation 14, for advanced assessments due to their superior nutritional profiles. These formulations were further analysed for their polyunsaturated fatty acid composition, mineral and vitamin contents, antioxidant properties, and physical attributes like colour and texture. The polyunsaturated fatty acid composition for both formulations is provided in Table 2.

The analysis of polyunsaturated fatty acids (PUFAs) in Formulation 12 and Formulation 14 aimed to detail the fat composition noted in the proximate analysis results. In Formulation 12, each 100 g sample contained 5.74 g (80.88%) of Linoleic (cis) acid and 1.28 g (18.07%) of α-Linolenic acid. For Formulation 14, the composition per 100 g included 6.80 g (68.90%) of Linoleic (cis) acid (omega-6) and 3.01 g (30.52%) of α-Linolenic acid (omega-3). The statistical analysis showed no significant differences in these acids' quantities between both formulations. Given the critical role of these PUFAs in enhancing cognitive functions, their quantification was crucial. The high levels of these fatty acids can be attributed to the substantial inclusion of Sacha inchi *(Plukenetia volubilis)* oil in both formulations. Prior research on Sacha inchi *(Plukenetia volubilis)* oil revealed that it contains about 39.86% Linoleic (cis) acid and 42.71% α-Linolenic acid, accounting for nearly 83.00% of its total fat composition. Omega-3 fatty acids, particularly α-Linolenic acid, are essential for transporting ions and neurotransmitters across nerve cell membranes. Dong *et al.* (2020) noted that a deficit in omega-3 fatty acids could lead to other fats compensating, potentially reducing membrane fluidity, impairing synapse and dendrite functions, and altering neurotransmitter concentrations. This alteration can significantly affect brain performance. Furthermore, Dighriri *et al.* (2022) indicated that incorporating omega-3 and omega-6 fatty acids into diets enhances oxygen saturation and concentration in haemoglobin, improving cerebral blood flow. This enhancement is particularly beneficial in correcting early memory and learning challenges, especially in young children.

Table 2. Polyunsaturated fatty acid composition of the health bar

Formulation	Fatty acid profile (g /100 g sample)	
	Linoleic (cis)	α-Linolenic
12	5.74 [a]	1.28 [a]
14	6.80 [a]	3.01 [a]

Values with the same letters within the same column are not significantly different ($p < 0.05$).

Table 3. Mineral, vitamin and antioxidant levels of the health bar

Formulation	Analysis		
	Magnesium (mg/kg)	Vitamin E as alpha-tocopherol (mg/100g)	DPPH (% inhibition)
12	1166[a]	43 [a]	7.37 [a]
14	1152 [a]	80 [a]	8.91 [a]

Values with the same letters within the same column are not significantly different ($p < 0.05$).

3.3 Mineral, vitamin and antioxidant levels of health bar

Table 3 displays the content of magnesium, vitamin E as alpha-tocopherol, and the percentage of DPPH inhibition in the chosen health bar formulations (Formulation 12 and Formulation 14).

The magnesium levels for Formulation 12 and Formulation 14 were measured at 1166.0 mg/kg and 1152.0 mg/kg, respectively. These figures are marginally above those found by Munir *et al.* (2018), who reported about 1074 mg/kg. The Recommended Nutrient Intakes (RNI) indicate that children and adolescents of both sexes should consume at least 410.0 mg and 360 mg of magnesium, suggesting these bars could meet these needs. Compared to the RNI, both bars fell short in vitamin E content, with Formulation 12 providing 0.43 mg/100 g and Formulation 14 at 0.80 mg/100 g, against the advised 10.0 mg/100 g for males and 7.5 mg/100 g for females. Therefore, the bars could offer only about 4.3% (Formulation 12) to 5.7% (Formulation 14) of the RNI for vitamin E to both male and female adolescents.

DPPH (2,2-diphenyl-1-picrylhydrazyl) inhibition measured antioxidant activity was 7.37% for Formulation 12 and 8.91% for Formulation 14. This activity is notably less than in previous studies, where DPPH inhibition ranged from 12.40% to 26.04% (Yasinta, Yao & Chang, 2021). The DPPH assay, employing a stable radical to evaluate antioxidant scavenging capacity, signifies the antioxidant's ability to neutralise free radicals potentially harmful to brain function. Crucial micronutrients for enhancing cognitive abilities, such as magnesium, potassium, zinc, vitamin E, and B-complex vitamins, have been identified in earlier research (Tardy *et al.*, 2020). These nutrients are vital for cognitive health as they participate in the energy metabolism of brain cells, neurotransmitter synthesis, receptor binding, and maintenance of membrane-ion pumps (Huskisson, Maggini and Ruf, 2007). Hence, it is reasonable to suggest that the current formulations of these health bars can provide key nutrients beneficial for cognitive enhancement.

3.4 Texture and colour assessment of health bar

Evaluating texture and colour is crucial as they significantly influence consumer acceptance of health bars. The texture measurements for Formulation 12 and Formulation 14 revealed hardness values of 24.03 ± 2.49N and 23.59 ± 2.67N, aligning closely with earlier findings of 24.27 ± 0.29N and 25.14 ± 0.69N by Yasinta, Yao & Chang (2021). The firmness of these health bars is attributed to the solidification of sugar alcohol and its integration with moisture-absorbing date powder, leading to a denser structure. Nevertheless, this level of hardness falls within a desirable range, indicating ease of chewing (Parn *et al.*, 2015). In terms of colour, the health bars showed L*, a*, and b* values of 48.97 ± 0.84 and 44.02 ± 0.14 for lightness, 4.79 ± 0.11 and 6.62 ± 0.14 for redness, and 20.82 ± 0.60 and 24.70 ± 0.40 for yellowness, respectively. In colourimetric terms, L* values range from 0 to 50 for darker shades and 51 to 100 for lighter ones. Thus, both bars exhibited darker hues, primarily due to the caramelisation of sugar alcohol during their production (Lucas *et al.*, 2019). Furthermore, positive a* and b* values indicate the dominance of red and yellow tones, imparting an orange tint to the bars (Parn *et al.*, 2015).

4. Conclusion

The simplex lattice mixture design method effectively identified the optimal blend of date powder, Sacha inchi *(Plukenetia volubilis)* oil, and Moringa *(Moringa oleifera)* powder for crafting the health bar. Optimal formulations were achieved with two specific combinations: one comprising 12.50% w/w date powder, 5.00% w/w Sacha inchi *(Plukenetia volubilis)* oil, and 7.50% w/w Moringa *(Moringa oleifera)* powder, and the other consisting of 12.50% w/w date powder, 10.00% w/w Sacha inchi *(Plukenetia volubilis)* oil, and 2.50% w/w Moringa *(Moringa oleifera)* powder. These health bars not only stand out nutritionally — featuring low moisture but high in ash, protein, fats, carbohydrates, energy, and dietary fibre — but also excel in their content of crucial fatty acids, significant levels of magnesium and vitamin E (alpha-tocopherol), and notable antioxidant properties. As far as producing this health bar, it was challenging to find the best ingredients to cater for the nutrition needs whilst keeping its good taste, finding the best method to assemble the health bar and experimenting with the bar's flavour to be accepted in the market. Therefore, several suggestions to improve the health bar experiment can be made for future research, including finding other suitable ingredients to coat and bind the health bar, testing the shelf life of the health bar and carrying out detailed nutrition analysis on the health bar. Nevertheless, given these attributes of the produced bars, they are theoretically primed to enhance cognitive abilities in children and adolescents. They are poised to redefine the snack bar market, which traditionally prioritises energy provision over nutritional richness.

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