RESEARCH ARTICLE

Development of a healthy cookie to promote toddlers' brain development: *Brainy Bites*

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Abstract:

This study aims to develop a healthy cookie designed for toddlers. "*Brainy Bites"* was developed by incorporating ingredients that are linked with healthy brain development and improved cognitive function in early childhood. Proximate analysis revealed that Brainy Bites contain 67.71 ± 0.23 carbohydrate, 3.87± 0.07 crude protein, 18.51 ± 0.24 fat, 1.80 ± 0.01crude fiber, 1.63 ± 0.01 ash and 8.29 ± 0.10 moisture. Physical analysis done on *Brainy Bites* indicated that the developed cookie had 0.5 cm thickness, 3.7 cm width, 7.4 spread ratio, 18.18% bake loss and 1392.4 g hardness, respectively. There were significant difference ($p < 0.05$) in the nutrients content of *Brainy Bites* and the two cookies that were compared in which *Brainy Bites* contains significantly higher amount of crude protein, crude fiber and ash content . Brainy Bites will serve as a great snack for toddlers at home, nurseries or for travelling. The cookie will be accepted in the market and would be a better choice of snack for toddlers as it contains no added sugar and salt, and contains ingredients such as raisins, almonds and chia seeds that may help in the brain development among toddlers.

Keywords: Brain development, cookie, early nutrition, healthy snack, toddler

1. INTRODUCTION

Toddlers are children aged one to three years old who are highly curious and have a high sense of independence [1]. Toddlers should have a balanced, nutritious, and high energy meal as this is the age of rapid growth and development [2]. One of the most common nutrition challenges among toddlers is "picky eating" [3].

Picky eaters are prone to become under-nourished as they refuse to eat many types of food and tend to have meals that are unhealthy [4]. Picky eaters often have a poor intake of fruits and vegetables which lead to poor consumption of dietary fiber [5].

In this 21st century, most parents are concerned about their children's' cognitive and physical development [6]. One of the most important factors contributing to cognitive development in toddlers is nutritional intake [7]. Hence, parents nowadays are giving priority to provide their children with food that is important for their brain development [8]. Studies show that the important nutrients for brain development include iron, choline, vitamin B12, antioxidant such as resveratrol, Docosahexaenoic acid (DHA), α-linolenic acid (ALA), and Arachidonic acid (AA) [9-12].

Iron is an important micronutrient needed for healthy brain development as iron is essential for normal neurotransmitter development and production [13]. Insufficient intake of iron in the diet will affect the normal development of the central nervous system [14]. Choline is an essential nutrient for memory and brain development [12]. Choline is needed for the synthesis of neurotransmitter namely acetylcholine, phospholipids, and lipoprotein plus methyl group metabolism [12]. Providing choline during critical period of development will improve the child's memory.

Vitamin B_{12} is necessary to be taken during early childhood because of the importance in brain development of children [11]. Providing adequate amount of vitamin B_{12} in children would improve or enhance their brain performance as well as performance during school [11]. One of the antioxidants that have functioned with brain health is resveratrol which is a polyphenolic phytoalexin found abundantly from fruits such as grapes, berries and peanuts [15]. Resveratrol improves cognitive function, enhance psychomotor function, and reduce oxidative stress [10].

The major Long Chain Fatty Acids that are often linked with brain development are docosahexaenoic acid (DHA) which is an Omega 3 Fatty acid and the Arachidonic Acid (AA) which

is an Omega 6 fatty acid [9]. Research has also proven that DHA is also linked with visual functionality in healthy children [16].

Hence this study aimed to develop a nutritious cookie for toddlers using ingredients such as raisins, almonds, and chia seeds that are often linked with healthy brain development and cognitive performance in children. *Brainy Bites* will serve as a great snack for toddlers as it is convenient, nutritious and contains many ingredients that help in promoting a healthy brain development for the targeted age group.

2. METHODOLOGY

2.1. Product Development

Table 1 shows the cookie formulation of the product. The standard dough mixture of 462.18 g yielded approximately 80 cookies. There were four types of flour used: whole meal flour, white flour, cornstarch, and rice flour with the proportion of 42 g, 70 g, 15 g, and 9.88 g respectively. Wheat germ (10g), chia seed (2g), almond (55g), raisins (55g), banana (85g), canola oil (25g and Omega 3 fortified eggs (35g) were added in the mixture.

Table 1. Cookie formulation in this study.

Ingredients	Amounts (g) / 462.18 g
Whole Meal Flour	42
White Flour	70
Cornstarch	15
Rice Flour	9.88
Wheat Germ	10
Chia Seed	2
Raisins	55
Banana	85
Almond	55
Canola Oil	25
Omega-3 Fortified Egg	35
Cinnamon	1.3
Vanilla Extract	2

Raisins, almonds, wheat germ and whole meal flour were first pre-dried in an oven at 170° C for three minutes. Next, raisins were cut into small bits using a knife and almond, wheat germ and whole grain flour were finely grounded using a dry blender. After this step, the 3 different type of flours (wheat flour, corn starch and rice flour) were mixed in a bowl together with all the other dry ingredients such as the chopped raisins, grounded ingredients and chia seeds. The whole banana was mashed with a spoon. All the wet ingredients such as the canola oil, egg, mashed banana was combined in a different bowl. Cinnamon and vanilla extract were added into the wet ingredients. The wet ingredient mixture was then combined with the dry ingredients and were kneaded into cookie dough. Once homogenized, the cookie dough was rolled to a thin layer and was cut using a cookie cutter to form a doughnut shape. The cookie was then baked at a temperature of 170° C for 10 minutes. Figure 1 shows the flow chart of the cookie development.

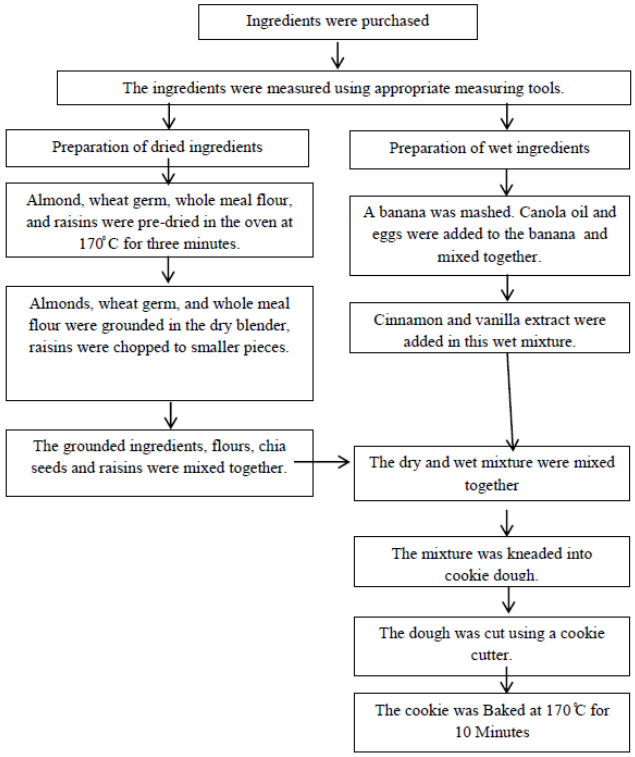

Figure 1. Flowchart of the development of Brainy Bites

2.2 Proximate Analysis

Proximate analysis was done on the developed cookie and the nutrient content was compared with two existing cookies in the market. Crude fiber, moisture and ash were determined by following the method from Association of Official Analytical Chemists, AOAC [17]. Crude protein was determined using Kjeldahl method while fat was determined using Soxhlet method. Carbohydrate content of the developed cookie was determined using calculation. The proximate analysis was done at the Food Analysis Laboratory, Centre of Nutrition and Dietetics Puncak Alam Campus, UiTM Selangor,

9.09
15.15
3.25
2.13
2.16
11.9
18.39
11.9
5.41
7.57
0.28
0.43

2.3 Physical Analysis

The physical analysis of the cookie was determined on the day of baking. The physical analysis done include thickness, width, spread ratio, bake loss and hardness. The thickness of the developed cookie was measured by stacking six cookies and measured using a measuring scale [18]. The cookies were restacked to obtain the average reading. The width of six cookies was also measured by laying them edge to edge [18]. They were rotated 90° and re-measured to obtain the average reading. The spread ratio of cookie was calculated by dividing the width and thickness of the cookie [19]. The bake loss of five cookies was measured for their weight before and after baking [20]. The hardness of cookie was measured by using texture analyzer (model TA.XT plus Stable Micro Systems, England) using a blade probe with a load cell of 5 kg applied at a crosshead speed of 60 mm/min [21]. The hardness of cookie was expressed in gram (g). A higher reading indicated greater force needed and therefore tougher cookie.

2.4 Comparison of Nutrient Content of The Developed Cookie with Two Selected Cookies Available in the Country for The Same Age Group.

The nutritional content of the newly developed cookie was compared with two selected cookies for the same age group. The two cookies that were chosen for comparison were chosen based on availability, age group and nutritional content.

2.5 Statistical Analysis

The data were analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. Descriptive statistics such as ANOVA was performed and reported.

3. RESULT AND DISCUSSION

3.1 Product Development

Figure 2 shows the final product of *Brainy Bites*. The selection of ingredients used to formulate this cookie took into consideration several factors such as its nutrient content, availability of the raw ingredients, good flavor, aroma, and baking quality as well. The ingredients were chosen based on their nutrient content related to nutrition that are associated with toddlers' brain development. Literature review was first done to identify which nutrients best help in enhancing brain development and which food ingredients contain these nutrients. In this recipe, there were no addition of sugar and sodium as sugar to promote health food choices for this age group.

Figure 2. Brainy Bites

3.2 Proximate Analysis

Proximate analysis was done on *Brainy Bites* and two other compared cookies for the same age group to analyze their nutrient content. Table 2 summarizes the results of the proximate analysis on the three cookies.

Table 2 shows the result of proximate analysis done on the three compared cookies. The results represent the mean ± standard deviation (SD) from duplicate[1], triplicate[2] and quadruplicate[3] samples. The results for every nutrient in every cookie depend on the ingredients incorporated in each cookie. The results indicate that 'Brainy Bites" has a significantly higher protein and fibre content compared to the other two control cookies.

Table 2. Nutrient content of *Brainy Bites*, Cookie B and Cookie C.

% Nutrients (per 100g)	Sample			p-value*
	Brainy Bites	Cookie B	Cookie C	
Carbohydrate[1]	67.71 ± 0.23	77.14 ± 1.19	57.77 ± 1.81	0.001
Crude Protein[3]	3.87± 0.07	2.92 ± 0.04	2.23 ± 0.06	0.000
Fat[1]	18.51 ± 0.24	13.19 ± 1.17	36.38 ± 1.84	0.001
Crude Fiber[1]	1.80 ± 0.01	1.70 ± 0.04	1.50 ± 0.06	0.012
Moisture[2]	8.29 ± 0.10	5.15 ± 0.03	2.34 ± 0.05	0.000
Ash[1]	1.63 ± 0.01	1.63 ± 0.01	1.31 ± 0.00	0.000

ANOVA significant at $p<0.05$

3.3 Physical Analysis

Physical analysis on *Brainy Bites* which included thickness, width, spread ratio, bake loss and hardness was conducted. Table 3 summarizes the physical characteristics for *Brainy Bites.*

Table 3. Physical analysis of *Brainy Bites*.

Physical Analysis	Brainy Bites
Thickness (cm)	0.5
Width (cm)	3.7
Spread ratio	7.4
Bake loss (%)	18.18
Hardness (g)	1392.4

The thickness of the cookie was 0.5cm each with the width of 3.7 cm measured using a measuring scale. This was done to ensure toddlers were able to hold the cookie and eat independently as they prefer to eat independently at this age. Therefore, giving autonomy to feed themselves could help them improve their skills especially eating skills [22].

A cookie with a high spread ratio (higher width and lower thickness) is considered a positive cookie characteristic [23]. *Brainy Bites* has an average spread ratio of 7.4. Due to the incorporation of high fiber ingredients, the amount of hydrophilic spot which binds water is high in the cookie dough making the dough's viscosity high and thus resulting in a reduced spread ratio [23]. The low spread ratio also might be due to the absence of sugar in the dough as sugar helps in increasing spread ratio by absorbing the moisture content of the cookie [24].

Texture is important to analyze a cookie's quality. The higher the hardness reading of a cookie, the more force is needed to break it. indicates that greater force thus tougher cookie texture. The average hardness of this developed cookie was 1392.4 g. A study reported that the hardness of a cookie

increased with the incorporation of whole meal wheat in which the cookie developed had a reading of 3670 g [23]. The result was higher than the result for *Brainy Bites*. The hardness of a cookie might be affected by the baking time too [21] and moisture content of a cookie [24]. Sugar addition in most cookie recipes will help to give the cookie its crispiness aside from adding sweetness [24]. However, In *Brainy Bites*, there was no addition of sugar. Therefore, this might be the reason why *Brainy Bites* was slightly hard.

3.3 Comparison of Nutrient Content in Brainy Bites with Selected Two Cookies for The Same Age Group.

Brainy Bites, Cookie B and Cookie C were compared for their nutrient content. As summarized in Table 2, one-way ANOVA* was done and it was found that there was significant difference ($p < 0.05$) for all the nutrients in the three cookies. Cookie B had the highest carbohydrate content followed by *Brainy Bites* and Cookie C. The values were 77.14 ± 1.19, 67.71 ± 0.23 and 57.77 ± 1.81, respectively. The high carbohydrate content of Cookie B might be due to the ingredients such wheat flour, sugar, banana, skim milk powder, apple puree, and barley malt extract. The lower carbohydrate results in *Brainy Bites* was due to the incorporation of ingredients such as a mixture of whole meal flour, white flour, cornstarch, rice flour and the usage of banana and raisins as the fruit and no additional sugar was added.

Brainy Bites contained the highest amount of crude protein followed by Cookie B and Cookie C. The mean percentage were 3.87 ± 0.07, 2.92 ± 0.04, and 2.23 ± 0.06, respectively. *Brainy Bites* contained the highest amount of crude protein because there was an incorporation of high protein ingredients such as egg, almond, whole meal flour, and wheat germ. Cookie B in cooperated skimmed milk powder while Cookie C used full cream milk powder as the protein source.

Cookie C contained the highest amount of fat followed by *Brainy Bites* and Cookie B. The mean percentage of fat were 36.38 ± 1.84, 18.51 ± 0.24, and 13.19 ± 1.17, respectively. Cookie C incorporated palm oil and full cream milk powder which added up to the high-fat content in the cookie. *Brainy Bites* fat content was mainly from canola oil and almond which were also good sources of monounsaturated fatty acid and polyunsaturated fatty acid. Cookie B fat content was mainly from palm oil.

Brainy Bites had the highest percentage of crude fiber followed by Cookie B and Cookie C which were 1.8 ± 0.01, 1.7 ± 0.04, and 1.5 ± 0.06, respectively. *Brainy Bites* was purposely made with ingredients high in fiber such as whole meal flour, wheat germ, chia seed, almond, raisins, and banana. This was to help toddlers receive some fiber as toddlers are mostly picky eaters and have a poor intake of vegetables and fruits that are main source of fiber [25]. Cookie B had added inulin while Cookie C might have obtained its fiber value from the wheat flour.

The percentage of moisture content in *Brainy Bites*, Cookie B and Cookie C were 8.29 ± 0.10, 5.15 ± 0.03, and 2.34 ± 0.05, respectively. The developed cookie contained the highest percentage of moisture compared to the other two. The high moisture content might be due to the high fiber content in the developed cookie because of the high-water binding capacity [26].

Brainy Bites had the highest percentage of ash followed by Cookie B and Cookie C. *Brainy Bites* was designed to be a functional cookie that helps in toddlers' brain development by incorporating various ingredients such as raisins, almonds and chia seeds that are linked with healthy brain development and enhanced cognitive function . The high ash content proved the availability of minerals in the developed product.

4. CONCLUSION

The development of a healthy cookie designed for toddlers that contains ingredient that are associated with good brain development and improved cognitive performance was successfully developed. Brainny Bites will serve as a great snack for toddlers at home, nurseries or for travelling as it is a healthy choice of snack for toddlers. The cookie will be accepted in the market and would be a better choice of snack for toddlers as it contains no added sugar and salt, a higher amount of crude protein, crude fiber and ash compared to the other two cookies that were designed for the same group which are widely available in the market.

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