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A Healthy Cereal Granola Bar Formulation from a Mixture of Thai Local Rice Flour, Job's Tears Flour, and Black Sesame Seeds †

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Abstract: The objective of this study was to investigate the optimal ratio of a mixture of Thai riceberry rice flour, Job's tears flour, and black sesame seeds in developing a healthy cereal granola bar. Based on the experimental mixture design of 10 formulations of a granola bar, the mixture ratio of riceberry rice flour, Job's tears flour, and black sesame seeds affected the quality of the cereal granola bar in terms of physicochemical and sensory properties, and the differences were statistically significant ($p \leq 0.05$). The main ingredients of the granola bar formulation that was well-accepted were riceberry rice flour (5%), Job's tears flour (35%), and black sesame seeds (5%). The peak viscosity of Rapid Visco Analyzer (RVA) of riceberry rice flour and Job's tears flour was 943.67 ± 49.60 cP and 1329.00 ± 10.71 cP, respectively. This product showed the highest overall liking score of 7.27 ± 0.64 with a water activity of 0.53 and moisture content of 11.54%. These results suggest that the prepared local cereal granola bar can be a promising food product with nutritional value and antioxidant content. The addition of Job's tears flour and riceberry rice flour improved the texture of the granola bars.

Keywords: healthy granola bar; cereal bar; mixture design method

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1. Introduction

The consumption of healthy and functional foods has increased in recent years. Globally, there is a high demand for healthy cereal bar products due to the increasing popularity of healthy and natural products, coupled with the growing consumption of cereals in various countries. Cereal granola bar consumption is increasing because of its ability to meet requirements, such as high content of nutrients, nutraceutical compounds, and antioxidants, of health-conscious consumers. They also offer several health benefits such as lowering cholesterol levels, aiding in weight-loss attempts, increasing energy levels, regulating digestion, and improving heart health [1]. The granola bar or cereal bar is a healthy food consumed as a meal. Granola bars usually contain small pieces of many ingredients glued together using a binder and then pressed into a block, some of which are coated with a binder [2]. In Thailand, a granola bar is a local-style snack called krayasart, khoa tan, thua tat, and thua krajok, which contains a few types of Thai local raw materials, such as peanut and sesame seeds bound with high contents of sugar syrup

[3]. However, these Thai granola bars are very sweet owing to the high volume of binders. The development of new granola bars by mixing many types of nutritional local raw materials, such as Thai rice, Job's tears, and black sesame, in Thailand is still limited. This was the first study to use high-nutritional-value Thai local raw materials such as riceberry rice flour, Job's tears flour, and black sesame, as described below.

Thai coloured indica rice (*Oryza sativa cv. Riceberry*) is a modified rice variety that is a cross-species between Hom Nil rice and Khoa Dok Mali rice 105. Riceberry rice has a dark purple colour, high content of antioxidants, such as beta-carotene, gamma-oryzanol, vitamin E, omega-3, tannin, iron, zinc, and folate, and low-to-medium glycaemic index values) [4,5,6]. Job's tears are nutrition-rich grains with a high content of carbohydrates, vitamins, and minerals such as vitamin B, calcium, and phosphorus and belong to the same family of rice (Tanimura, 1961) [5]. Job's tears are harvested in many areas of India, China, and Southeast Asia and processed into various types of foods such as nutraceutical foods because of their therapeutic effects against cancer, high cholesterol levels, and obesity. Several studies have reported that coixenolide Job's tears inhibit tumour growth [7,8,9] and lower blood cholesterol levels [8]. Black sesame seeds (*Sesamum indicum L.*) have valuable nutritional components, including vitamin E (γ-tocopherol and α-tocopherol), vitamin B6, iron, iodine, zinc, copper, phosphorus, potassium, calcium, fibre, and amino acids (methionine and tryptophan). They are rich in lignans such as sesamin and sesamolin, which inhibit and reduce the absorption and formation of cholesterol and increase the efficiency of the liver [10]. Developing healthy cereal bar formulations from local raw materials not only assists consumers in meeting dietary nutritional requirements but also helps local producers with their product management. This study aimed to investigate the optimal ratio of a mixture of Thai coloured indica rice flour or riceberry rice flour, Job's tears flour, and black sesame seeds for developing a healthy granola bar that relied on Thai food safety law.

2. Materials and Methods

2.1. Materials

The dry-soak-steam (DSS) method was used to prepare riceberry rice flour [11]. Riceberry rice (1 kg) was heated in a hot air oven at 100 °C for 10 min and soaked in water at 60 °C for 30 min with a rice: water ratio of 1:1.5. Next, it was washed immediately with cold water (5 °C); the excess water was removed, and the sample was dried in a hot air oven at 90 °C for 4–5 h or until the water activity of rice was less than 10% [12]. The riceberry rice from the DSS method was cooled down and milled with a grinder to produce riceberry rice flour. This flour was then packed in an aluminium foil bag and refrigerated at 4 °C for quality analysis and use as a raw material. Job's tears flour was prepared by soaking 1 kg of Job's tears grains in water at room temperature (25 °C) at a ratio of 1:3 for a period of up to 7 h. The soaked grains were drained and steamed at 100 °C for 30 min, washed immediately with cold water (5 °C). Then, the excess water was removed, and the grains were dried in a hot air oven at a temperature of 80 °C for 6 h or until the final moisture content of these grains was less than 10%–14% [13]. The Job's tears were cooled down, ground with a blender to make flour, packed in an aluminium foil bag, and kept refrigerated at 4 °C until further use as materials and samples for quality analysis. Black sesame seeds (1 kg) were washed with water, drained, air-dried, roasted in a pan at 80–85 °C, stirred until cooked, cooled down, packed in an aluminium foil bag, and stored at 4 °C for quality analysis and use as materials for product development. All samples were analysed for their proximate composition (water activity (a.w.), moisture content, ash, fat, protein, fibre, and carbohydrates) by following the standard Association of Official Agricultural Chemists (AOAC, 2005) [14] procedures.

2.2. Pasting Properties Analysis

Pasting properties of all flour samples were analyzed using a Rapid Visco Analyzer (RVA) (RVA-4 D, Newport Scientific, New South Wales, Australia) according to AACC method No. 61-2 (AAAC, 2000) [15] and characterized using RVA model 4D (Newport Scientific). The sample with a moisture content of 14% was passed through a 120-mm mesh sieve. The sieved sample (3.000 ± 0.005 g) was treated with aluminum solution (25 ± 0.005 g of aluminum, 11% concentration), mixed using a plastic mixing blade, and analyzed using Rapid Visco Analyzer standard program no. 1. The starting temperature was set at 50 °C for (0−1 min), which was then increased (12.2 °C/min) to 95 °C within 2.5 min, decreased to 50 °C (12.2 °C/min), and maintained at 50 °C for 2.1 min. The agitation speed of the RVA paddle was kept constant at 160 rpm throughout the experiment.

2.3. Product Development

The materials used for granola bar product development were separated into two groups: Group A included major ingredients, and Group B contained minor ingredients. The ingredients in Group A were riceberry rice flour, Job's tears flour, and black sesame seeds, while those in Group B were from our preliminary product development and included a fixed proportion of jujube, raisin, ground cashew nut, peanut butter, cocoa powder, honey, and salt in the weight percentages of 20, 20, 10, 10, 2, 5, and 0.5, respectively. The simplex-lattice design mixture method was used to calculate the granola bar formulae using the software package Design-Expert version 6.0 Software (Stat Ease, Inc., Minnesota, MN, USA) [16]. Group A contained a fixed mixture ratio of main ingredients at a range of 5%–30% for riceberry flour, 10%–35% for Job's tears flour, and 5%–30% for black sesame seeds.

2.4. Physical and Chemical Analysis

The colour of granola bars was expressed as the L* (light), a* (red), and b*(blue) values according to the Hunter system using Konica Minolta CR-300 Chroma Meter (Minolta, CR-300, Osaka, Japan). The a* is the opposition between red and green, and b* between yellow and blue. The colour values of all samples were determined in triplicates. Texture profile analysis (TPA) was performed using a texture analyser (Model TA-XT plus, Stable Micro System, Ltd., London, England) to measure hardness (kg) and shear for obtaining firmness of granola bar by cutting test using a blade set with a knife having a length, thickness, and width of 90 0.01 × 0.5 0.01 × 70 + 0.01 mm, pre-test speed of 2 mm/s, and post-test speed of 10 mm/s with five analyses per sampling. Hardness tests were performed on granola bars measuring 30 0.5 × 30 0.5 × 15 0.5 mm. The chemical analyses were performed to estimate the proximate composition (a.w., ash, fat, protein, and available carbohydrate contents) of all samples according to the methods of AOAC [14].

2.5. Sensory Analysis

Fifty panelists who were familiar with the granola bar association of food choice and eating practice with health performed sensory analysis using a 9-point hedonic scale. All samples were coded with three-digit numbers randomly assigned and served at room temperature (25 °C). The granola bars were evaluated on the attributes of appearance, colour, flavour, taste, texture, and overall liking. The granola bar that was sensorially accepted as the best formula was assessed again at room temperature by semi-trained panelists aged 20 to over 40 years old (20-25 = 50%, 26-30 = 2%, 31-35 = 18; 36-40 = 16%; >40 = 14%). The ratio of males to females was about 22:78.The scores of the 9-point hedonic scale represented the overall liking of each product and the decision to buy these products. The study was conducted in individual booths with white lighting. The granola bar was served in pieces of 5 × 3 cm.

2.6. Statistical Analyses

The Kolmogorov-Smirnov test was used to test the normality of the data. Data were analysed using one-way analysis of variance (ANOVA) and compared using Duncan's New Multiple Range Test (DMRT) at a 95% confidence interval with a two-tailed p-value. The experimental design for sensory evaluation followed a randomized complete block design (RCBD), and samples were analysed in triplicates. Sensory data were analysed using ANOVA and compared using DMRT at a statistical confidence level of 95% to select the best formula from the highest score of products liked by the consumers. The best formulation was selected for further studies.All statistical analyses were performed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA) [17].

3. Results

All materials used in the mixture design study were prepared as described in Section 2.1. The riceberry rice flour, Job's tears flour, and black sesame seeds were processed and analysed using proximate analysis. The limitation of this study was the natural chemical structure of the raw materials. The nutritional formulation could change depending on the area of production of the raw materials.

3.1. Materials

The results showed that the moisture content of riceberry rice flour, Job's tears flour, and black sesame seeds were 6.32, 5.86, and 2.52%, whereas the a.w. values were 0.19, 0.26, and 0.38, respectively (Table 1).

Table 1. Chemical and nutritional properties of riceberry rice flour, Job's tears flour, and black sesame seeds.

Chemical compositions	Ingredients		
	Riceberry rice flour	Job's tears flour	Black sesame seeds
A.w.	0.19c ± 0.00	0.26b ± 0.00	0.38a ± 0.00
Moisture (%)	6.32a ± 0.02	5.86b ± 0.01	2.52c ± 0.03
Protein (%)	10.60b ± 0.06	7.86b ± 0.35	15.43a ± 1.01
Fat (%)	4.74b ± 0.48	3.92b ± 0.22	57.78a ± 0.43
Fiber (%)	0.53b ± 0.17	0.92a ± 0.17	0.54b ± 0.06
Ash (%) ns	9.88 ± 0.54	10.87 ± 1.35	11.17 ± 0.20
Carbohydrate (%)	66.25b ± 0.19	71.57a ± 0.62	12.56c ± 1.16

a,b,c Values with different superscript letters in a column are significantly different ($p \leq 0.05$); ns No significant differences between treatments ($p > 0.05$); A.w. = Water activity.

The mixture design method was used to calculate the formulae for creating the range of optimal mixture of ingredients (10 formulations of a granola bar), as shown in Table 2. The positioning of all experimental formulations produced using a mixture design with the three main components of a granola bar, which are Thai coloured indica rice flour, Job's tears flour, and black sesame seeds.

Table 2. Different granola bar formulations were produced using the mixture design method.

Formulation	Riceberry rice flour (%)	Job's tears flour (%)	Black sesame seeds (%)
1	5	35	5
2	5	10	30
3	30	10	5
4	5	22	18
5	18	22	5
6	18	10	18
7	14	18	13
8	9	27	9
9	9	14	22

10	22	14	9

3.2. Pasting properties of various flours

The peak viscosity of riceberry rice flour and Job's tears flour was 943.67 ± 49.60 cP and 1329.00 ± 10.71 cP, respectively (Table 3).

Table 3. Pasting properties of riceberry rice flour and Job's tears flour.

Pasting properties	Flours	
	Riceberry rice flour	Job's tears flour
Peak viscosity (cP)	943.67 ± 49.60	1329.00 ± 10.71
Final viscosity (cP)	1017.33 ± 31.96	2524.33 ± 4.50
Setback (cP)	162.67 ± 15.84	1389.00 ± 5.10
Breakdown (cP)	89.00 ± 19.30	193.67 ± 5.91

The breakdown values of riceberry rice flour and Job's tears flour were 89.00 ± 19.30cP and 193.67 ± 5.91 cP, respectively. The final viscosity of riceberry rice flour and job's tears flour was 1017.33 ± 31.96 cP and 2524.33 ± 4.50 cP, respectively. The breakdown values indicate the ease of breaking starch granules when heated after reaching maximum swelling at peak viscosity.

3.3. Physical and Chemical Analyses of Granola Bars

Table 4 shows the results of the physical analysis of the 10 formulations of the granola bar. It was observed that the colour values of each formulation were significantly different ($p \leq 0.05$). Adding black sesame seeds and riceberry rice flour decreased lightness (L*) and increased redness (a*), whereas the b* value was negative. The b* value represents the blueness; the higher the negative b* value, the more intense the blueness.The results showed that the products containing a higher riceberry rice flour content exhibited an increase in b* values. Furthermore, it was found that the content of Job's tears flour affected the texture in terms of the hardness of the final product. The higher the Job's tears flour content, the harder were the final products prepared with the 10 formulations.

Table 4. Physical characteristics of 10 formulations of granola bar.

Formulation	Color values			Hardness (N)
	L*	a*	b*	
1	33.91^{b}1 ± .36	3.86^{abc} ± 0.11	-1.77^{ab} ± 1.29	89.36^{a} ± 0.62
2	33.56^{b} ± 1.03	3.05^{c} ± 0.04	-2.72^{bc} ± 0.49	38.86^{f} ± 1.03
3	33.44^{b} ± 0.22	3.98^{ab} ± 0.11	-2.49^{bc} ± 0.00	47.09^{c} ± 1.96
4	34.13^{a} ± b1.46	3.54^{bc} ± 0.20	-2.03^{abc} ± 0.82	59.80b^{c} ± 0.32
5	36.46^{a} ± 2.57	3.47^{bc} ± 0.54	-1.16^{a} ± 0.57	62.19^{c} ± 0.54
6	34.10^{ab} ± 0.66	3.13^{c} ± 0.10	-2.53^{bc} ± 0.40	59.49^{b} ± 0.50
7	33.55^{b} ± 0.20	3.62^{abc} ± 0.02	-2.58^{bc} ± 0.13	56.48^{d} ± 1.90
8	31.80^{b} ± 1.29	4.36^{a} ± 0.92	-2.46^{abc} ± 0.30	55.72^{d} ± 0.19
9	32.06^{b} ± 0.70	3.67^{abc} ± 0.36	-2.29^{abc} ± 0.12	35.82^{g} ± 1.03
10	32.09^{b} ± 1.39	3.67^{abc} ± 0.43	-3.12^{c} ± 0.20	40.93^{f} ± 1.32

a,b,c Values with different superscript letters in a column are significantly different ($p \leq 0.05$).

In Table 5, the analysis of the chemical properties of the 10 formulations showed statistical differences ($p \leq 0.05$) in the mean values of a.w., which ranged between 0.47–0.57, and moisture contents, which ranged between 10.88%–12.70%. The mean percentage contents of protein, fat, fibre, ash and carbohydrate were between 9.51–13.57, 8.26–15.54, 2.20–6.14, 1.95–2.72, and 51.98–65.23, respectively.

The results indicated that the chemical qualities of the 10 formulations of granola bar depended on the ratio of riceberry rice flour, Job's tears flour, and black sesame seeds. The formulation of granola bars with a high ratio of a mixture of Job's tears flour and riceberry rice flour resulted in high amounts of fibre, ash, and carbohydrate in the final products, whereas those with a high content of black sesame seeds contributed to high amounts of fat, protein, and ash in the final products. Thus, the chemical properties of the final product depend on the natural chemical properties of the raw materials because some of the raw materials are rich in proteins, carbohydrates, fats, vitamins, and minerals.

3.4. Product Development

As shown in Table 6, the sensory evaluation of 10 formulations of granola bars using a 9-point hedonic scale by 30 panellists in terms of appearance, colour, flavour, and overall liking was statistically different ($p > 0.05$). The granola bar formulation no. 1 with the major ingredient mixture ratio of Job's tears flour (35%), riceberry rice flour (5%), and black sesame seeds (5%) received the highest overall liking score (7.27 ± 0.64) from the panellists. In addition, this granola bar formulation had the most appreciated score in appearance (7.37 ± 0.89), colour (7.27 ± 1.08), flavour (6.87 ± 1.33), taste (6.70 ± 1.32), and texture (6.57 ± 1.20). Therefore, in this study, formulation no. 1 was selected and processed as the finished product or prototype for commercial processing.

Table 5. Chemical analyses of the 10 formulations of granola bar.

Formulation	Water activity (a.w.)	Moisture content (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Carbohydrate (%)
1	$0.53^{d} \pm 0.00$	$11.54^{cde} \pm 0.16$	$12.26^{b} \pm 0.17$	$9.65^{de} \pm 1.09$	$3.27^{bcd} \pm 0.64$	$2.10^{f} \pm 0.06$	$61.15^{b} \pm 2.01$
2	$0.47^{g} \pm 0.01$	$11.33^{de} \pm 0.31$	$13.57^{a} \pm 0.18$	$15.54^{a} \pm 0.27$	$4.73^{b} \pm 1.03$	$2.72^{a} \pm 0.02$	$51.98^{e} \pm 1.67$
3	$0.56^{b} \pm 0.00$	$12.70^{a} \pm 0.39$	$9.51^{d} \pm 0.83$	$8.26^{e} \pm 0.46$	$2.11^{d} \pm 0.02$	$2.01^{f} \pm 0.05$	$65.23^{a} \pm 1.07$
4	$0.49^{f} \pm 0.00$	$10.88^{e} \pm 0.20$	$11.79^{b} \pm 0.01$	$13.83^{abc} \pm 0.94$	$2.65^{cd} \pm 0.37$	$2.45^{b} \pm 0.02$	$58.45^{c} \pm 0.36$
5	$0.55^{c} \pm 0.00$	$12.54^{ab} \pm 0.22$	$10.79^{c} \pm 0.63$	$8.66^{de} \pm 0.11$	$2.20^{d} \pm 0.18$	$2.03^{f} \pm 0.04$	$63.63^{a} \pm 0.39$
6	$0.57^{a} \pm 0.00$	$11.85^{bcd} \pm 0.04$	$11.99^{b} \pm 0.30$	$14.73^{ab} \pm 1.65$	$6.80^{a} \pm 1.14$	$2.32^{d} \pm 0.01$	$52.47^{e} \pm 0.04$
7	$0.56^{b} \pm 0.01$	$11.89a^{bcd} \pm 0.41$	$11.74^{b} \pm 0.09$	$10.49^{d} \pm 0.45$	$6.14^{a} \pm 0.13$	$2.05^{f} \pm 0.01$	$57.88^{cd} \pm 0.37$
8	$0.55^{c} \pm 0.01$	$12.28^{abc} \pm 0.93$	$11.99^{b} \pm 0.11$	$12.68^{c} \pm 0.05$	$3.60^{bcd} \pm 0.49$	$2.11^{e} \pm 0.05$	$57.85^{cd} \pm 0.47$
9	$0.51^{e} \pm 0.00$	$12.36^{abc} \pm 0.15$	$11.40^{bc} \pm 0.22$	$9.47^{de} \pm 0.27$	$4.15^{bc} \pm 0.33$	$1.95^{g} \pm 0.01$	$60.74^{b} \pm 0.06$
10	$0.56^{b} \pm 0.00$	$11.79^{bcd} \pm 0.52$	$13.15^{a} \pm 0.26$	$13.61^{bc} \pm 0.76$	$3.25^{bcd} \pm 0.36$	$2.38^{c} \pm 0.01$	$56.10^{d} \pm 1.08$

^{a,b,c} Values with different superscript letters in a column are significantly different ($p \leq 0.05$).

Table 6. Sensory evaluation of the 10 formulations of granola bar.

Formulation	Appearance	Color	Texture	Flavor	Taste	Overall liking
1	$7.37^{a} \pm 0.89$	$7.27^{a} \pm 1.08$	$6.57^{ns} \pm 1.20$	$6.87^{a} \pm 1.33$	$6.70^{ns} \pm 1.32$	$7.27^{a} \pm 0.64$
2	$7.00^{abc} \pm 1.02$	$6.93^{ab} \pm 1.23$	$6.63^{ns} \pm 1.16$	$6.80^{a} \pm 1.24$	$6.70^{ns} \pm 1.32$	$6.73^{ab} \pm 1.57$
3	$7.27^{ab} \pm 1.05$	$6.93^{ab} \pm 1.26$	$6.77^{ns} \pm 1.20$	$6.67^{a} \pm 1.16$	$6.53^{ns} \pm 1.63$	$6.67^{b} \pm 1.50$
4	$6.97^{abc} \pm 1.00$	$6.77^{b} \pm 1.28$	$6.63^{ns} \pm 1.13$	$6.80^{a} \pm 1.27$	$6.80^{ns} \pm 1.45$	$6.93^{ab} \pm 1.29$
5	$7.00^{abc} \pm 1.15$	$6.93^{ab} \pm 1.14$	$6.43^{ns} \pm 1.31$	$6.50^{ab} \pm 1.33$	$6.37^{ns} \pm 1.52$	$6.53^{b} \pm 1.28$
6	$6.33^{c} \pm 1.10$	$6.87^{ab} \pm 0.94$	$6.23^{ns} \pm 1.33$	$6.30^{ab} \pm 1.51$	$6.43^{ns} \pm 1.38$	$6.67^{b} \pm 1.32$
7	$6.83^{bc} \pm 1.15$	$6.57^{b} \pm 1.04$	$6.27^{ns} \pm 1.39$	$5.93^{b} \pm 1.66$	$6.50^{ns} \pm 1.70$	$6.57^{b} \pm 1.52$
8	$6.73^{c} \pm 1.26$	$7.00^{ab} \pm 0.00$	$6.60^{ns} \pm 1.35$	$6.70^{a} \pm 1.15$	$6.63^{ns} \pm 1.30$	$6.60^{b} \pm 1.07$
9	$6.70^{c} \pm 1.15$	$6.57^{b} \pm 1.20$	$6.43^{ns} \pm 1.57$	$6.77^{a} \pm 1.52$	$6.90^{ns} \pm 1.42$	$6.93^{ab} \pm 1.46$
10	$7.03^{abc} \pm 1.03$	$6.77^{b} \pm 1.17$	$6.63^{ns} \pm 1.22$	$6.40^{ab} \pm 1.50$	$6.63^{ns} \pm 1.47$	$7.03^{ab} \pm 1.15$

^{a,b,c} Values with different superscript letters in a column are significantly different ($p \leq 0.05$).

3.5. Sensory Evaluation of Finished Product

Formulation no. 1 of granola bar received an overall liking score of 7.86 ± 1.73 with the best acceptance in the attributes of appearance (8.16 ± 1.41), followed by texture (7.94 ± 1.53), taste (7.83 ± 1.66), and odour (7.62 ± 1.05) by the 100 panellists. The overall acceptability of the product was approximately 87%, and the decision to purchase the finished product (at 25 Thai baht) was approximately 56% (Table 7).

Table 7. Mean sensory ratings on a 9-point hedonic scale and percentage consumer acceptance of finished product (granola bar formulation no. 1).

Attribute	Mean ± S.D.
Appearance	8.16 ± 1.41
Texture	7.94 ± 1.53
Taste	7.83 ± 1.66
Odor	7.62 ± 1.05
Overall liking	7.86 ± 1.73
Consumer acceptance	Percentage
Acceptable	87
Not acceptable	13
Consumer decision on purchasing	Percentage
Willing to purchase	56
Not willing to purchase	44

The consumer's reason for not purchasing was the lower protein content of the finished product than the commercial products in the market. Furthermore, the results of the quality of formulation of no. 1 products in Table 5 and sensory tests in Table 6 agreed with the criteria of Thai community product standard of Jolly Chewy Peanut (Sweetened Bean and Rice) (TCPS Number 709/2547): the moisture contents were less than 12% and the score of sensory tests was equal or more than three points for all attributes [18]

4. Discussion

The final viscosity positively correlated with amylose content that is negatively correlated with starch granule swelling and setback value. Setback value indicates the hardness of the cooled gel paste; a high setback value responds to the high retrogradation of starch [19,20]. The pasting properties results showed that the improvement in granola bar texture was higher after Job's tears flour addition than after riceberry rice flour addition. This could be attributed to Job's tears originating from non-glutinous grains that contained a high percentage of amylose ranging between 15.9%–25.8%, as reported by Li and Corke (1999) [21]. They also found that the food product containing Job's tears was harder in texture and showed adhesiveness lower than other products with glutinous Job's tears. Moreover, it was reported that denaturing natural proteins and changing the main structure of proteins increased the hardness of the product [22]. The semi-trained panelists from our study, with a gender ratio of 22:78, who were between the ages of 20 and over 40. A comparison with the Dahal et al. (2022) study revealed no discernible gender differences in food preferences. However, there was a gender difference in the eating habits observed. There was no correlation found between eating habits and food preferences and health [23].

5. Conclusions

Out of the 10 formulations of granola bars, formulation no. 1 received the highest hedonic ratings. It had an overall liking score of 7.27 ± 0.64, water activity of 0.53, and 11.54% moisture content. Its nutritional quality and characteristics complied with the Thai community product standard (TCPS) of Jolly Chewy Peanut (Sweetened Bean and Rice). From the sensory evaluation questionnaires, the consumer decides to purchase the

finished product was about 56%. The addition of Job's tears flour and riceberry rice flour improved the texture of the granola bars. The prepared local cereal granola bar could be a promising food product with nutritional value and antioxidant content. In the future, this study can help develop new products for specific consumer groups, such as the fortification of the products' dietary nutrition without changing the formulation.

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References

1. Grand View Research, 2019. Cereal bar market size, share & trends analysis report by product (snacks bars, energy & nutrition bars), by distribution channel (hypermarkets & supermarkets, convenience stores), and segment forecasts, 2019–2025. Available online https://www.grandviewresearch.com/industry-analysis/cereal-bar-market (accessed 25 July 2023)
2. Wongpiyachon, S., Sukviwat, W.,. Health food product from defatted rice bran: snack bar of puffed rice with defatted rice bran. Proceedings of Rice and Temperate Cereal Crops Annual Conference, Bangkok, 142–154 (2009).
3. Songtip, P., 2007. Development of snack bar from brown rice and herb. Graduate School, Kasetsart University, Bangkok, Thailand.
4. Chaisiricharoenkul, J.; Tongta, S., Intarapichet, K.-O. Structure and chemical and physicochemical properties of Job's tear (Coix lacryma-jobi L.) kernels and flours. *Suranaree J. Sci. Technol.* **2011,** 18, 109–122.
5. Settapramote, N.; Laokuldilok, T., Boonyawan, D., Utama-ang, N. Physiochemical, antioxidant activities and anthocyanin of riceberry rice from different locations in Thailand. *FABJ*, **2018**, 6, 84–94.
6. Tanimura, A. Studies on antitumor component in the seeds of Coix lachrymal-jobi. Var. Ma-yuen Stapf. II.: The Structure of Coixenolide. *Chem. Pharm. Bull.***1961,** 9, 47–53
7. Zhu, Y.P.; Su, Z.W., Li, C.H. Growth-inhibition effects of oleic acid, linoleic acid, and their methyl esters on transplanted tumors in mice. *J. Natl. Cancer Inst.* **1989**, 81, 1302–1306.
8. Numata, M.; Yamamato, A., Moribayashi, A., Yamada, H. Antitumor components isolated from the Chinese herbal medicine Coix lachrymal-jobi. Planta Med. 1994, 60, 356–359.
9. Huang, B.W., Chiang, M.T., Yao, H.T., Chiang, W.C.The effect of adlay oil on plasma lipids insulin and leptin in rat. *Phytomedicine.* **2005**, 12, 433–439.
10. Morris, J.B. 2002. Food, industrial, nutraceutical, and pharmaceutical uses of sesame genetic resources, in Janick, J., Whipkey, A. (Eds.), Trends in New Crops and New Uses. ASHS Press, Alexandria, pp. 153–156.
11. Ozai-Durrani, A.K., 1948. Quick cooking rice and process for making same, U.S. patent 2. 438-939, 6 April.
12. Intipunya, P., Ouichanpagdee, P., 2010. Development of texture modified brown rice and stabilization using microwave. Faculty of Agro-Industry Chiang, Mai University, Chiang Mai, Thailand.
13. Naiwikul, O. Wheat: Science and technology. Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand., 2004.
14. AOAC, Official methods of analysis of the association of analytical chemists international, eighteenth ed. Association of Official Analytical Chemists, Arlington, 2005.
15. AACC. Method 61-02.01. Determination of the pasting properties of rice with the Rapid Visco Analyzer. In AACC International Approved Methods of Analysis, 11th ed. AACC international, St.Paul, MN, U.S.A, 2000.
16. Buruk Şahin, Y., Aktar Demirtaş, E., Burnak, N., Mixture design: A review of recent applications in the food industry. *Pamukkale Univ. Muh. Bilim. Derg*. **2016.** 22, 297–304.

17. SPSS, SPSS for Windows, Version 15.0. SPSS Inc, Chicago. 2011.
18. Thai Industrial Standards Institute, 2004. Thai community product standard of Jolly Chewy Peanut (Sweetened bean and rice), TCPS Number 709/2547.
19. Chrastil, J. Chemical and physicochemical changes of rice during storage at different temperatures. *J. Cereal Sci.* **1990.** 11, 71-85.
20. Tester, R.F.; and Morrison, W.R. Swelling and gelatinization of cereal starches. I. Effects of amylopectin, amylose, and lipids. *Cereal Chem*., **1990,** 67, 551-557.
21. Li, J., Corke, H. Physicochemical properties of normal and waxy Job's tears (*Coix lachrymal-jobi L*.) starch. *Cereal Chem.* **1999,** 76, 413–416.
22. Pornkitprasarn, T.; Naiwikul, O., Comparison of chemical and physical properties of Job's tears flour and starch. *Kasetsart J. (Soc. Sci.).* **1987.**, 21, 371–377.
23. Dahal, M., Basnet; A., Khanal, S., Baral, K. ; and Dhakal, S., Gender Difference in Food Choice and Eating Practice and Their Association with Health among Students of Kathmandu, Nepal. *Journal of obesity*, **2022**, 2340809.