Asia-Pacific Journal of Science and Technology :Volume :30 Issue :05 Article ID :APST-30-05-13 Research Article

APST

Asia-Pacific Journal of Science and Technology

https//:www.tci-thaijo.org/index.php/APST/index

Published by Research and Innovation Department,
Khon Kaen University, Thailand

Sensory and nutritional evaluation of value-added cereal bars made from indigenous Thai agricultural resources: a community enterprise development model

Chaiyasit Punfujinda[1], Rath Chombhuphan[1], Surachai Khankaew[2], Sawai Boukaew[3], Amornrat Anunvrapong[4], and Krittin Chumkaew[1, *]

[1]Faculty of Home Economics Technology, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand
[2]Faculty of Mass Communication Technology, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand
[3]Faculty of Agricultural Technology, Songkhla Rajabhat University, Songkhla, 90000, Thailand
[4]Faculty of Liberal Arts, Rajamangala University of Technology Krungthep, Bangkok, 10120, Thailand
*Corresponding author: krittin_c@rmutt.ac.th

Received 11 September 2024
Revised 25 September 2024
Accepted 1 May 2025

Abstract

Cereal bars are a type of snack food characterized by their stick-like shape. They are primarily made from cereals, dried fruits, and sweeteners. In this study, cereal bar products were developed as new value-added products for potential commercialization through community enterprises. The appropriate ratios of fried banana and fried taro used to replace fried *khao mao* (pounded unripe rice) were investigated through sensory quality evaluation. It was found that CB50, in which 50% of fried *khao mao* was substituted with fried banana (w/w), and CT50, with 50% substituted with fried taro (w/w), received the highest sensory acceptance scores. Nutritional analysis showed that CB50 provided 100 kcal per serving (20 g), and CT50 provided 110 kcal per serving (20 g), with each package containing five servings. A consumer acceptance test involving 100 participants (final product) was conducted. No significant differences *($p \geq 0.05$)* were observed between CB50 and CT50 in terms of appearance, color, smell, taste, texture, and overall acceptance. Additionally, a packaging satisfaction survey found no statistically significant differences *($p \geq 0.05$)* in overall satisfaction scores. Based on the checklist questionnaire assessing consumer attitudes, 100% of respondents indicated acceptance of the product.

Keywords: Cereal bars, Local agricultural products, Product development, Snack

1. Introduction

In recent years, significant transformations have been observed in food consumption patterns. A growing preference for foods that are natural, convenient, and rich in nutritional value has been reported among consumers [1]. This behavioral shift has been linked to the trend of "snackification" which has led to the increased popularity of portable snack products such as cereal bars [2]. Rather than being consumed solely to satisfy hunger, cereal bars have increasingly been selected for their ability to provide essential nutrients [3]. Globally, the cereal bar market has experienced rapid expansion, driven by the rising demand for functional and health-oriented snacks. In response to this trend, the development of innovative products has been emphasized. This includes the incorporation of novel ingredients and the implementation of sustainable packaging strategies to improve both nutritional value and consumer appeal. Purchasing decisions regarding cereal bars are frequently influenced by factors such as flavor and nutritional benefits [4,5] and, due to intense market competition, ongoing innovation has been promoted to add value and achieve product differentiation [6].

Cereal bars have been selected as a source of healthy alternative snacks. They are recognized for their nutritional value, including low energy, high protein, high dietary fiber, low fat content, essential minerals, and various vitamins. A wide range of ingredients is typically included, such as sugar, cereals, fruits, and seeds, among

others [1,7]. Characterized by their light weight, compact size, and portability [2,8], these products are generally produced to be consumed as morning or afternoon snacks, or as supplements to main meals. As a result, cereal bars have been developed globally [9]. To meet global interest, various types of cereal bar products have been developed using diverse raw materials, for instance, high-protein composite cereal bars have been formulated primarily from cereal-based ingredients [10]. In another example, functional breakfast cereal bars have been created containing nine different cereal varieties to enhance nutritional diversity [11]. Cereal bars have also been produced using legumes such as black beans and red beans, which contribute additional protein and fiber content [12]. Furthermore, in Brazil, cereal bars containing licuri nut (*Syagrus coronata*) have been introduced as a novel functional snack [13], while, in Southern Thailand, a high-energy cereal bar has been developed using regionally sourced ingredients, including roasted Bambara nuts, sesame seeds, puffed rice, banana pieces, and dates. In these formulations, maize syrup and honey have been incorporated as natural sweeteners to improve palatability and energy density [14].

The development of cereal bar products using cereals and locally cultivated fruits in substantial quantities is aligned with Thailand's agricultural identity. As one of the world's leading exporters of rice and tropical fruits [15], Thailand provides abundant resources suitable for value-added food product innovation. Furthermore, this approach aligns with the sufficiency economy philosophy, which promotes sustainable agricultural development [16]. Within this context, the Mit Samphan Group community enterprise in Chachoengsao Province has produced a range of solar-dried agricultural products, including rice, banana, taro, and fruits such as madan, tamarind, mango, and bilimbi.

Therefore, the development of cereal bars from locally available agricultural resources has been regarded as both a challenge and an opportunity to maximize community benefit. Particular attention has been paid to the potential of ingredients that are cultivated within the community for use in cereal bar production. Such development is anticipated to lead to new product lines for the Mit Samphan Group community enterprise, which may influence consumer purchasing behavior and contribute to increased household income. Moreover, the use of local fruits in cereal bars has been identified as both feasible and advantageous, as it can enhance socioeconomic potential while meeting the rising demand for ready-to-eat, high-consumption snack products [13].

However, although the demand for nutritious cereal bars has continued to grow, limited research has been conducted on the use of Thai local agricultural products, such as fried banana and fried taro, as key components in cereal bar formulations. These ingredients were selected based on their local abundance, consumer familiarity, desirable sensory properties, and potential to enhance the value of underutilized crops within community enterprises. While fried *khao mao* (pounded unripe rice) has traditionally been used, concerns regarding production complexity and cost have led to the exploration of partial substitution with alternative local ingredients.

In this study, the research problem being addressed is the lack of empirical data on the sensory attributes and nutritional profiles of cereal bars in which fried banana and fried taro are used as partial substitutes for fried *khao mao*, particularly in formulations that achieve the highest sensory acceptance. The study was designed to develop cereal bar prototypes incorporating local ingredients, evaluate their sensory quality, analyze the nutritional content of the most preferred formulations, assess consumer acceptance, and explore their potential for commercialization within the context of community enterprise development.

2. Materials and methods

2.1 Raw material and preparation

The cereal bar formulation utilized a variety of raw materials sourced from the local community. Fried *khao mao* was prepared by deep-frying the grains in hot oil at 170°C until they became fluffy and crispy, then drained and cooled. Mature unripe Namwa bananas (Musa ABB group), a common local cultivar, were sourced from the community, peeled, washed, sliced into strips, and deep-fried at 170°C until crispy, then drained of excess oil. Similarly, fresh taro from the community was peeled, cleaned, sliced into strips, deep-fried under the same conditions, and set aside.

Dried fruits, including *madan*, tamarind, mango, and bilimbi, were prepared by solar drying, which was carried out by the Mit Samphan Group community enterprise. Other essential ingredients, such as cashew nuts, pumpkin seeds, coconut milk, and sugar cane juice, were sourced from local community markets. Refined sugar and palm sugar were procured from the Mitr Phol brand, glucose syrup was obtained from the Fancy Carp brand (Charoenworrakit Ltd.), and salt was acquired from the Prung Thip brand (Refined Salt Industry Co., Ltd.).

The control formula, consisting of 100% fried *khao mao*, was used as the baseline for comparison. The improved formulations (CB25–CB75 and CT25–CT75) were developed by gradually substituting fried *khao mao* with fried banana or fried taro at varying ratios. These substitutions aimed to enhance the sensory properties of the cereal bars. The criteria for formula enhancement were based on preliminary sensory evaluations, including appearance, taste, texture, and overall acceptance.

Table 1 presents the formulations of cereal bars developed in this study. Each formulation includes different substitution ratios of fried *khao mao* with either fried banana or fried taro. The ingredient quantities are expressed in grams.

Table 1 Formulation of cereal bars from local agricultural products

Ingredients (g)	Control	CB25	CT25	CB50	CT50	CB75	CT75
Fried *khao mao*	1,400	1,050	1,050	700	700	350	350
Fried banana	-	350	-	700	-	1,050	-
Fried taro	-	-	350	-	700	-	1,050
Dried *madan*	180	180	180	180	180	180	180
Dried tamarind	180	180	180	180	180	180	180
Dried mango	180	180	180	180	180	180	180
Dried bilimbi	180	180	180	180	180	180	180
Cashew nuts	500	500	500	500	500	500	500
Pumpkin seeds	300	300	300	300	300	300	300
Coconut milk	250	250	250	250	250	250	250
Sugar cane juice	500	500	500	500	500	500	500
Sugar	100	100	100	100	100	100	100
Palm sugar	50	50	50	50	50	50	50
Glucose syrup	375	375	375	375	375	375	375
Salt	10	10	10	10	10	10	10

Control = 100% fried *khao mao*; CB25, CB50, CB75 = fried *khao mao* substituted with 25%, 50%, and 75% fried banana (w/w), respectively; CT25, CT50, CT75 = fried *khao mao* substituted with 25%, 50%, and 75% fried taro (w/w), respectively.

The production process for cereal bars involves mixing fried *khao mao*, fried banana or taro, dried fruits, and other dried ingredients with a prepared syrup made from coconut milk, sugar cane juice, and palm sugar. The mixture is pressed into molds, baked at 80°C for 1 h and cooled at ambient temperature. After that, it was filled with a high-barrier packaging bag (aluminum foil laminated with polyethylene (PE/AL/PE) material) and sealed with nitrogen gas-flushed packaging (NFP) using a heat-sealing method to prevent oxidation and retain crispness and flavor [17]. The full process is illustrated in Figure 1, with actual production steps shown in Figure 2.

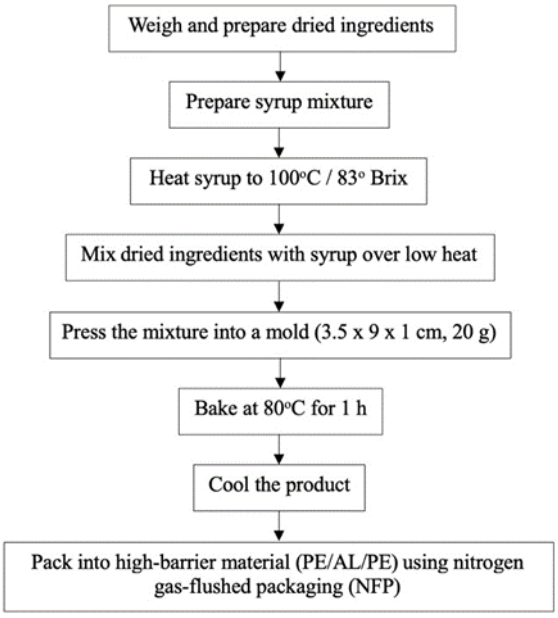

Figure 1 Flow chart of the cereal bar production process.

Figure 2 Step-by-step photographs of the cereal bar production process: (A) dried ingredients were weighed and prepared; (B) all dried components were mixed together; (C) the syrup mixture was heated to 100°C; (D) dried ingredients were added into the syrup; (E) the mixture was stirred until homogeneous; (F) the mixture was pressed into a rectangular mold; (G) the molded bars were baked at 80°C for 1 h; (H) the bars were cooled and packed into high-barrier material (PE/AL/PE) bags; (I) the packaging was heat sealed using a nitrogen gas-flushed packaging (NFP); and (J) the final cereal bar products were ready for storage and distribution.

2.2 Sensory analysis

In this study, sensory analysis was conducted to evaluate the quality of cereal bar samples formulated with fried banana and fried taro as substitutes for fried *khao mao*. The objective was to determine the appropriate substitution ratio by comparing the control samples with CB25, CB50, and CB75 (banana-based), and CT25, CT50, and CT75 (taro-based) formulations. A total of 50 untrained panelists participated in the evaluation. The test was conducted in triplicate using a 9-point hedonic scale (1 = dislike extremely to 9 = like extremely) to assess appearance, color, smell, taste, texture, and overall acceptance [10,18]. A single-factor experimental design was used to investigate the effects of different substitution levels (25%, 50%, and 75% w/w) on the sensory attributes. The average scores for each attribute were considered in selecting the optimal formulations, with CB50 and CT50 achieving the highest scores and being selected for further nutritional and consumer acceptance analysis. Prior to participation, the research objectives were clearly explained to the participants, who then signed a written informed consent form [18,19]. The sensory evaluation was conducted in accordance with standard food testing protocols, ensuring voluntary participation. Participants were informed that all samples contained only food-grade ingredients and there were no known allergens or safety concerns.

2.3 Nutrition analysis

For the nutritional analysis, two samples, CB50 and CT50, were selected based on their highest sensory acceptance scores. The nutritional values were analyzed according to the Thai Recommended Daily Intake (Thai RDI), both per 100 g and per serving (20 g). The purpose of this analysis was to generate accurate information for nutrition labeling, which was placed inside the product packaging to support a certification request from the Chachoengsao Provincial Public Health Department and the Thai FDA. A total of 17 nutritional parameters were examined at Bureau Veritas AQ Lab (Thailand) Limited, which is an ISO/IEC 17025 certified laboratory specializing in agricultural and food product testing. The parameters included total energy, energy from fat, total carbohydrate [20], total fat, saturated fat, cholesterol, protein, dietary fiber, sugars, sodium, calcium, iron, moisture, ash, vitamin B1, and vitamin B2 [21], as well as vitamin A [22].

2.4 Consumer acceptance

The CB50 and CT50 formulations, which received the highest sensory evaluation scores, were selected for further consumer acceptance testing. Both products were processed and packaged with inner packaging made of high-barrier material (PE/AL/PE) bags, each with a thickness of 117±3.54 micrometer, a width of 5.5 cm, and a length of 15 cm. The packages were sealed using a heat-sealing machine equipped with a nitrogen gas-flushed packaging (NFP). The outer packaging was produced using paperboard with an average thickness of 0.85 mm and a weight of 250 g/m². A lock-end carton structure in a folding box format was applied and printed using an offset printing system, with five units placed per box. The product was considered ready for commercialization. The packaging and consumer testing process is illustrated in Figure 3. Consumer acceptance testing was conducted with 100 untrained panelists [23] in Phanom Sarakham District, Chachoengsao Province. Accidental sampling was used, and data were collected using structured questionnaires divided into four parts:

Part 1 collected personal data including gender, age, and education using a checklist format [24].

Part 2 involved a sensory evaluation of the final products using a 9-point hedonic scale (1 = dislike extremely to 9 = like extremely), assessing appearance, color, smell, taste, texture, and overall acceptance [10,18].

Part 3 examined satisfaction with packaging, which included three aspects: satisfaction with the inner packaging, outer packaging, and overall packaging. A 5-point Likert scale was used: 1 = Dislike very much, 2 = Dislike, 3 = Somewhat like, 4 = Like, and 5 = Like very much [25]. Satisfaction levels were interpreted using the following scale: 1.00–1.49 = Dislike very much, 1.50–2.49 = Dislike, 2.50–3.49 = Somewhat like, 3.50–4.49 = Like, and 4.50–5.00 = Like very much [26].

Part 4 assessed consumer attitudes toward the product, including acceptance, perceived price appropriateness, purchase intent, and purchase motivation, using a checklist format [18].

Participants were informed of the study's objectives and provided written informed consent. No personally identifiable information was collected, and participants were free to withdraw at any time. All data were anonymized to ensure confidentiality [18,19].

Figure 3 Products of cereal bars from local agricultural products, the finished product is ready for distribution on the market. A: (CB50) cereal bar from fried *khao mao* substituted with 50% fried banana w/w, B: (CT50) cereal bar from fried *khao mao* substituted with 50% fried taro w/w.

2.5 Product sales data

Sales information for the two products, CB50 and CT50, which demonstrated consumer acceptance and were prepared for market release, was gathered between January and June 2024. The data, covering a period of five months, were compiled into the financial report (income–expenditure account) of the Mit Samphan Group community enterprise [27].

2.6 Data analysis

Data from the sensory quality tests were analyzed using analysis of variance (ANOVA) and Duncan's New Multiple Range Test (DNMRT) to compare the means at a 95% confidence level. Data from the consumer acceptance study were analyzed using appropriate statistical methods. Respondents' personal information and consumer attitudes toward the product were analyzed using frequency and percentage values. The sensory evaluation of the final product and satisfaction with the product were analyzed using the paired-samples t–test to compare differences between the two products, with a confidence level of 95%. All statistical analyses were performed using SPSS software, version 22.

3. Results and discussion

3.1 Sensory quality analysis of cereal bars products

Table 2 presents the results of the sensory quality evaluation. The CB50 formulation, consisting of fried *khao mao* and 50% fried banana, received the highest scores across all sensory attributes from 50 panelists. Statistically significant differences *($p < 0.05$)* were observed when compared with the control, CB25, and CB75. Similarly, the CT50 formulation, in which 50% of fried *khao mao* was substituted with fried taro (w/w), received the highest preference scores among the CT25, CT50, and CT75 samples. Based on these findings, it can be concluded that CB50 and CT50 were the most acceptable formulations in their respective comparison groups. These results suggest that substituting 50% of fried *khao mao* with either fried banana or fried taro offers an optimal balance in texture, taste, and overall sensory appeal. This may be attributed to the physical characteristics of fried banana and fried taro. After frying, both ingredients exhibit low moisture content and a firm, crispy texture. However, when used in excessive amounts, they may lead to a dense and overly tough product structure, negatively impacting chewability and consumer satisfaction. These findings are consistent with the study by Samakradhamrongthai et al. [14] which reported that high-energy cereal bar (HCB) products received hedonic scores ranging from "dislike slightly" to "like very much." The proportions of fruits, cereals, and sweeteners in cereal bar formulations were shown to influence consumer preference. Similarly, Kaur et al. [1] concluded that varying the content of flaxseed, quinoa, and brown rice in cereal bars resulted in differences in appearance and taste, ultimately affecting sensory acceptance. As a result, CB50 and CT50 were selected for further development and used in subsequent stages of the study.

Table 2 Sensory quality analysis of cereal bars from local agricultural products.

Attributes	Control	CB25	CB50	CB75
Appearance	$6.90^{b}\pm0.92$	$7.00^{b}\pm1.17$	$7.87^{a}\pm1.00$	$7.20^{b}\pm0.92$
Color	$7.20^{a}\pm0.88$	$7.53^{a}\pm0.68$	$7.63^{a}\pm0.85$	$6.63^{b}\pm1.03$
Smell	$6.10^{c}\pm0.96$	$7.43^{b}\pm0.50$	$8.13^{a}\pm0.73$	$8.07^{a}\pm0.86$
Taste	$6.57^{c}\pm0.72$	$7.07^{b}\pm0.86$	$8.17^{a}\pm0.69$	$7.33^{b}\pm0.99$
Texture	$6.30^{c}\pm0.65$	$7.30^{b}\pm0.79$	$7.93^{a}\pm0.74$	$6.40^{c}\pm0.56$
Overall acceptance	$6.43^{c}\pm0.81$	$6.87^{b}\pm0.81$	$8.20^{a}\pm0.92$	$7.00^{b}\pm0.64$
Attributes	Control	CT25	CT50	CT75
Appearance	$7.17^{b}\pm0.69$	$7.20^{b}\pm0.99$	$8.00^{a}\pm1.01$	$7.43^{b}\pm0.89$
Color	$7.40^{ab}\pm0.89$	$7.67^{a}\pm0.71$	$7.83^{a}\pm0.83$	$6.97^{b}\pm1.29$
Smell	$6.27^{c}\pm0.78$	$7.40^{b}\pm0.56$	$8.17^{a}\pm0.87$	$8.33^{a}\pm0.80$
Taste	$6.67^{c}\pm0.71$	$7.13^{b}\pm0.86$	$8.07^{a}\pm0.78$	$7.47^{b}\pm1.07$
Texture	$6.43^{c}\pm0.62$	$7.23^{b}\pm0.77$	$7.90^{a}\pm0.88$	$6.53^{c}\pm0.68$
Overall acceptance	$6.63^{c}\pm0.71$	$7.17^{b}\pm1.02$	$8.23^{a}\pm0.81$	$7.13^{b}\pm0.77$

Data (n = 50). Values are means ± standard deviations. Values with different superscripts within the same column are significantly different at a 95% confidence level *($p<0.05$)*. Control: cereal bar from 100% fried pounded unripe rice, CB25: cereal bar from fried *khao mao* substituted with 25% fried banana w/w, CT25: cereal bar from fried *khao mao* substituted with 25% fried taro w/w, CB50: cereal bar from fried *khao mao* substituted with 50% fried banana w/w, CT50: cereal bar from fried *khao mao* substituted with 50% fried taro w/w, CB75: cereal bar from fried *khao mao* substituted with 75% fried banana w/w, CT75: cereal bar from fried *khao mao* substituted with 75% fried taro w/w.

3.2 Nutrition analysis of cereal bars products

Table 3 presents the nutritional composition of the CB50 and CT50 cereal bars, analyzed per 100 g and per serving (20 g). Both products were found to exhibit similar nutritional profiles, with CT50 displaying slightly higher values in most categories. The total energy content per serving was 100 kcal for CB50 and 110 kcal for CT50, which aligns with the recommended daily snack calorie intake of approximately 200 kcal [28,29]. Nutritional analysis indicated that consuming one serving (1 piece or 20 g) per day provides nutrients that comply with the Thai Recommended Daily Intake (Thai RDI) for individuals aged six years and older, without exceeding the recommended daily limits. These values were calculated based on a standard daily energy requirement of 2,000 kcal, which includes the following limits: total fat less than 65 g per day, saturated fat less than 20 g per day, cholesterol less than 300 mg per day, total carbohydrate 300 g per day, dietary fiber 25 g per day, and sodium less than 2,000 mg per day [30].

Notably, neither product contained cholesterol, and both provided moderate amounts of dietary fiber. CB50 contained 1 g of dietary fiber per serving (4% of Thai RDI), while CT50 contained less than 1 g (3% of Thai RDI). The protein content was relatively low, with 1 g and 2 g per serving in CB50 and CT50, respectively. Total fat content was moderate, with CB50 providing 5 g (8% Thai RDI) and CT50 providing 6 g (9% Thai RDI) per serving. These nutritional values are comparable to those reported by Samakradhamrongthai et al. [14] for high-energy cereal bars, although the total energy content in our products (514–532 kcal per 100 g) was lower than the 645.50 kcal per 100 g reported in their study. The energy values observed also align with findings by Silva de Paula et al. [31] who reported approximately 100 kcal per serving in cereal bars fortified with dietary fiber and omega-3.

Importantly, both CB50 and CT50 were found to comply with Thai RDI guidelines for various nutrients when consumed as a single serving. These products may be considered suitable snack options within a balanced diet, offering energy and essential nutrients without exceeding daily recommended limits for fat, sugar, and sodium. However, while convenient and portion-controlled, these cereal bars should be consumed as complementary snacks rather than substitutes for main meals to ensure adequate overall nutrient intake.

Table 3 Nutrition Labeling-Thai RDI.

Nutrition values	CB50			CT50		
	Per 100 g	Per serving (20 g)	% Thai RDI	Per 100 g	Per serving (20 g)	% Thai RDI
Total energy (kcal)	514	100	-	532	110	-
Energy from fat (kcal)	238	50	-	263	50	-
Total fat (g)	26.40	5	8	29.20	6	9
Saturated fat (g)	10.60	2	10	12.90	2.50	13
Cholesterol (mg)	ND	0	0	ND	0	0
Protein (g)	7.11	1	-	8.35	2	-
Total carbohydrate (g)	62.10	12	4	59.10	12	4
Dietary fiber (g)	5.13	1	4	3.47	Less than 1	3
Sugars (g)	22.10	4	-	22.50	4	-
Sodium (mg)	594	120	6	568	115	6
Vitamin A (μg)	ND	-	0	ND	-	0
Vitamin B1 (mg)	<0.05	-	0	<0.05	-	0
Vitamin B2 (mg)	0.07	-	0	0.07	-	0
Calcium (mg)	158	-	4	149	-	4
Iron (mg)	1.81	-	2	1.91	-	2
Moisture (g)	2.82	-	-	1.53	-	-
Ash (g)	1.62	-	-	1.85	-	-

ND: Not detected, Serving size: 1 piece (20 g), Servings per container: 5 pieces (100 g). CB50: cereal bar from fried *khao mao* substituted with 50% fried banana w/w, CT50: cereal bar from fried *khao mao* substituted with 50% fried taro w/w.

3.3 Consumer acceptance of cereal bar products

Personal data from 100 respondents showed that 77% were female and 23% were male. In terms of age, 35% were between 41–50 years, 27% were aged 51–60 years, 19% were aged 31–40 years, 8% were aged 60 years and over, 6% were between 20–30 years, and 5% were under 20 years old. Regarding education level, 75% held a bachelor's degree, 22% had completed secondary education or lower, and 3% held a master's degree.

A sensory quality evaluation of the final product was conducted using the 9-point hedonic scale, as illustrated in Figure 4. The results showed that there were no statistically significant differences *($p \geq 0.05$)* between CB50 and CT50 in any of the sensory attributes. The average scores for CB50 ranged from 8.00 to 8.21, while those for CT50 ranged from 8.01 to 8.28. Specifically, the mean ± standard deviation for appearance was 8.08 ± 0.89 for CB50 and 8.12 ± 0.92 for CT50; color was rated at 8.11 ± 0.85 and 8.01 ± 0.86, respectively; smell at 8.17 ± 0.85 and 8.26 ± 0.88; flavor at 8.21 ± 0.68 and 8.28 ± 0.79; texture at 8.00 ± 0.89 and 8.09 ± 0.74; and overall acceptance at 8.06 ± 0.90 and 8.17 ± 0.75. These findings suggest that both cereal bar formulations were equally well accepted by consumers. The comparable scores may be due to the similar proportions and ingredients used in both formulations, which include fried *khao mao*, cereals, dried fruits, and sweeteners. The main distinction between the two lies in the use of fried banana in CB50 and fried taro in CT50. Ingredients used in cereal bar production are known to influence sensory perception and consumer preference. The present findings are consistent with those of Samakradhamrongthai et al. [14] who reported that taste, sweetness, texture, and crispiness are key sensory attributes that affect product acceptance and purchasing decisions. Additionally, Padmashree et al. [10] noted that nutritious energy bars, such as granola bars, chewy cereals, organic bars, and fruit bars, possess favorable organoleptic qualities that positively influence consumer decisions when these products are available in the market.

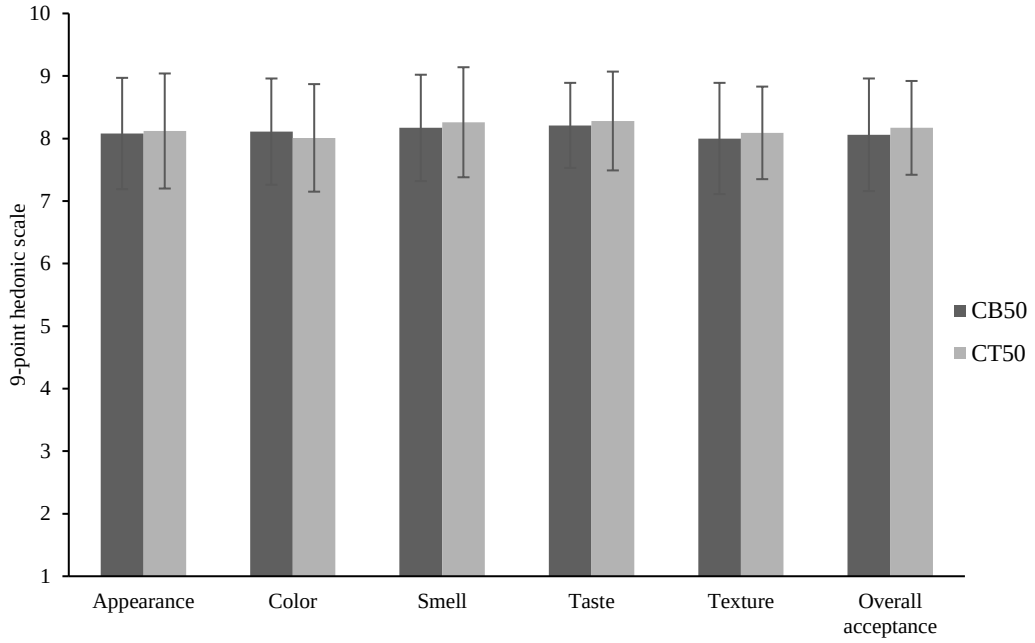

Figure 4 Final product tasting test results using a 9-point hedonic scale. Data (n = 100) were expressed as mean ± standard deviations. The result showed a non-significant difference *($p \geq 0.05$)*. CB50: cereal bar from fried *khao mao* substituted with 50% fried banana w/w, CT50: cereal bar from fried *khao mao* substituted with 50% fried taro w/w.

A comparison of consumer satisfaction with packaging as shown in Figure 5; there was no statistically significant difference between consumers in the CB50 and CT50 packaging satisfaction groups at the level *($p \geq 0.05$)* in all three areas: Satisfaction with inner packaging, satisfaction with outer packaging, and overall satisfaction with packaging. CB50 has a satisfaction score between 4.32–4.46, which is also on the Like level, while CT50 has a satisfaction score between 4.39–4.49, which is also on the Like level. Therefore, it can be concluded that consumers are satisfied with the packaging of both products at a level of like, allowing both products to be released to the market. In line with the suggestions of Cortina-Mercado [32], it has been suggested that packaging plays an important role in product marketing. Good brand location communication and standardized packaging can increase product sales and influence consumers' product decisions.

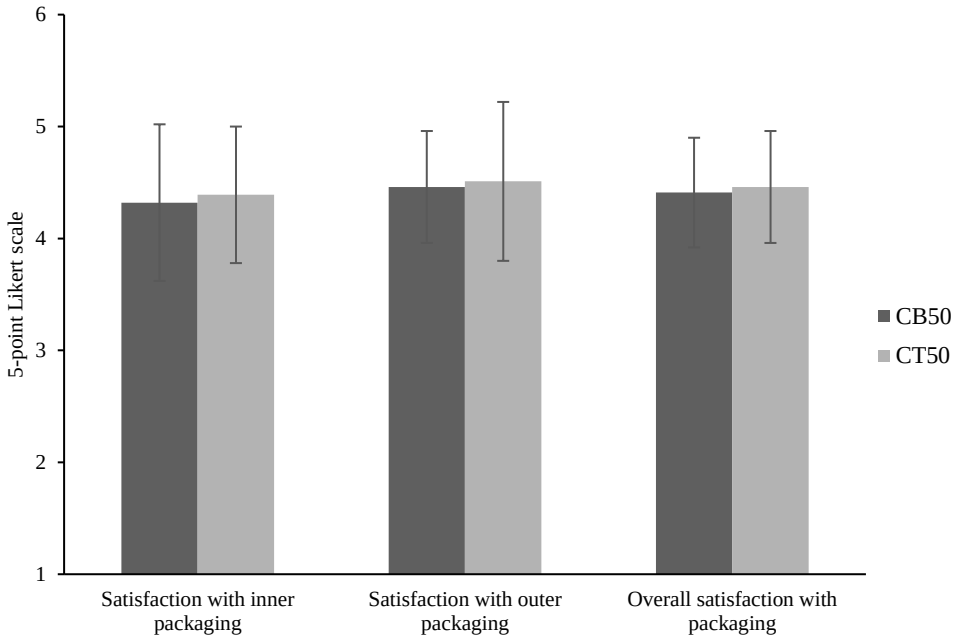

Figure 5 Packaging satisfaction study results using a 5-point Likert scale. Data **(**n = 100**)** were expressed as mean ± standard deviations. The result showed a non-significant difference *(p≥0.05)*. CB50: cereal bar from fried *khao mao* substituted with 50% fried banana w/w, CT50: cereal bar from fried *khao mao* substituted with 50% fried taro w/w.

Consumer attitudes toward the cereal bar products were examined, and the results revealed the following findings. A total of 100% of respondents accepted the product. Among them, 85% considered the price to be appropriate, while 15% did not. In addition, 90% indicated that they would purchase the product upon its release, whereas 10% remained uncertain. The reasons given for purchasing the product included adding value to local fruits grown in the community (26%), health benefits (24%), pleasant taste (20%), novelty and visual appeal (17%), and support for community enterprise initiatives (13%). These findings are consistent with a study by Srebernich et al. [33] which reported that consumers accepted cereal bar products and expressed purchase intention ranging from 54% to 64%. The current study demonstrates the feasibility of developing cereal bars using local agricultural ingredients such as rice, cereals, and dried mixed fruits sourced from Chachoengsao province, Thailand. The resulting products received high levels of consumer acceptance, supporting the utilization of local resources in food processing and contributing to sustainability within community enterprises. These results align with the work of Samakradhamrongthai et al. [14] who developed high-energy cereal bars using local ingredients derived from food industry by-products. Their formulations included southern rice, banana slices, dates, honey, and cornstarch, which were found to be acceptable to consumers and associated with high purchase intent. Similarly, de Arruda et al. [34] noted that the nutritional value and ease of consumption of cereal bars have contributed to their increasing popularity in response to growing consumer demand.

3.4 Results of collecting data on cereal bar product sales

Table 4 shows that over a 6-month period from January to June 2024, the Mit Samphan Group community enterprise sold a total of 1,800 boxes of cereal bar products, consisting of 900 boxes each of CB50 and CT50, with total revenue of USD 3,857.14. The average monthly income of approximately USD 642.86 reflects the product's strong sales potential at the community level.

These results suggest that the cereal bar project could be scalable and transferable to other local enterprises, especially those aiming to create value-added products from regional agricultural resources. The financial viability demonstrated here can serve as a model for similar initiatives in other provinces. It shows how community enterprises can leverage local ingredients, combined with basic food processing technology, to produce appealing consumer products and generate additional income.

The sales success of these products also highlights the role of community-driven innovation in supporting rural entrepreneurship and promoting sustainable agri-food systems. This is in line with Van Meerkerk et al. [35] who state that community enterprises are local operations driven by people in the community that promote the use of knowledge, local wisdom, creativity, and appropriate technology to add value to raw materials and resources.

The goal is to create and sell products that generate income for families and foster self-reliance within the community.

Table 4 Product sales financial report.

Sales period (months)	CB50		CT50		Total Price (USD)
	Quantity sold out (package)	Price (USD)	Quantity sold out (package)	Price (USD)	
January	100	214.29	100	214.29	428.57
February	100	214.29	100	214.29	428.57
March	100	214.29	100	214.29	428.57
April	200	428.57	200	428.57	857.14
May	200	428.57	200	428.57	857.14
June	200	428.57	200	428.57	857.14
Total	900	1,928.57	900	1,928.57	3,857.14

Product sales financial report within five months, from January to June 2024 [39]. CB50: cereal bar from fried *khao mao* substituted with 50% fried banana w/w, CT50: cereal bar from fried *khao mao* substituted with 50% fried taro w/w. The exchange rate used for calculation is 1 USD = 35 THB.

4. Conclusions

This research successfully developed two cereal bar products, CB50 and CT50, using local agricultural ingredients from Chachoengsao Province. The findings demonstrated the potential for value-added processing of locally sourced agricultural commodities. Both products exhibited favorable sensory qualities and nutritional profiles, conformed to Thai RDI guidelines, and received high levels of consumer acceptance. The success of these products provides direct benefits to the Mit Samphan Group community enterprise and holds broader implications for local economic development and sustainable agri-food processing in the region. This study contributes to the existing body of knowledge on snack food product development and offers practical insights for community-based enterprises aiming to leverage local ingredients in value-added food production. Future research should focus on optimizing the nutritional composition, evaluating shelf life, and assessing market acceptance across broader consumer segments to improve product competitiveness and sustainability. However, this study did not include microbiological or physical quality assessments due to limitations in resources and its primary focus on sensory and nutritional aspects. These quality parameters are essential for ensuring food safety and product stability and should therefore be incorporated into future research to strengthen the scientific basis of cereal bar development.

5. Acknowledgements

The authors would like to express their sincere gratitude to the Faculty of Home Economics Technology, Rajamangala University of Technology Thanyaburi, for providing essential facilities and laboratory support. This research was financially supported by a grant from the Office of the Permanent Secretary, Ministry of Higher Education, Science, Research and Innovation, Thailand.

6. Conflicts of interest

The authors declare that there is no conflict of interest.

7. References

[1] Kaur R, Ahluwalia P, Sachdev PA, Kaur A. Development of gluten-free cereal bar for gluten intolerant population by using quinoa as major ingredient. J Food Sci Technol. 2018;55(9):3584-3591.

[2] Boukid F, Klerks M, Pellegrini N, Fogliano V, Sanchez-Siles L, Roman S, et al. Current and emerging trends in cereal snack bars: implications for new product development. Int J Food Sci Nutr. 2022;73(5):610-629.

[3] Rafiu A, Hassan CZ, Arifin N, Asma AR. Physico-chemical analysis of high fibre cereal bar formulated with glutinous rice flakes and sunnah foods. J Adv Food Sci Technol. 2015;2(2):47-58.

[4] Souiy Z, Zakhama N, Cheraief I, Hammami M. Nutritional, physical, microbial, and sensory characteristics of gluten- and sugar-free cereal bar enriched with spirulina and flavored with neroli essential oil. LWT. 2022; 169:113955.

[5] Onsri N, Numnuam P, Thongdee K, Karuya K, Puksuksakul A, Paekul N, Kumchoo S. The use of banana syrup as a substitute for caramel in cereal bar products. J Home Econ Technol Innov. 2024;3(1). 2821 –9880.

[6] de Barros GLRR, Sanches MAR, Barcia MT, Rodrigues D, Pertuzatti PB. Murici (*Byrsonima verbascifolia*): a high bioactive potential fruit for application in cereal bars. LWT. 2022; 160:113279.

[7] Appelt P, da Cunha MAA, Guerra AP, Kalinke C, de Lima VA. Development and characterization of cereal bars made with flour of jabuticaba peel and okara. Acta Sci. Technol. 2015;37(1):117-122.

[8] Allai FM, Dar BN, Gul K, Adnan M, Ashraf SA, Hassan MI, Pasupuleti VR, Azad ZRA. Development of protein rich pregelatinized whole grain cereal bar enriched with nontraditional ingredient: Nutritional, phytochemical, textural, and sensory characterization. Front Nutr. 2022; 9:870819.

[9] Faber MA, Yuyama LKO. Functional dietary cereal bar based an Amazon Fruits. J Nutr Food Sci. 2015;5(2):1-6.

[10] Padmashree A, Sharma GK, Srihari KA, Bawa AS. Development of shelf stable protein rich composite cereal bar. J Food Sci Technol. 2012;49(3):335-341.

[11] Sang-Ha H. Development and quality properties of cereal bars. Korean J Food Preserv. 2005;12(3):235-240.

[12] Maurer G, Fukuda G, Nielsen S. Development of bean-based granola bars and cereal. Cereal Foods World. 2005;50(1):27-32.

[13] Sommo M, de Aguiar LA, Raposo A, Saraiva A, Teixeira-Lemos E, Chaves C, Romão B. Development and rapid sensory descriptive characterization of cereal bars made with Brazilian licuri nut (*Syagrus coronata*). Foods. 2024;13(3):502.

[14] Samakradhamrongthai RS, Jannu T, Renaldi G. Physicochemical properties and sensory evaluation of high energy cereal bar and its consumer acceptability. Heliyon. 2021;7(8): e07776.

[15] Panuwet P, Siriwong W, Prapamontol T, Ryan PB, Fiedler N, Robson MG, Barr DB. Agricultural pesticide management in Thailand: status and population health risk. Environ Sci Policy 2012; 17:72-81.

[16] Kasem S, Thapa GB. Sustainable development policies and achievements in the context of the agriculture sector in Thailand. Sustain. Dev. 2012;20(2):98-114.

[17] Alwazeer D. Reducing atmosphere packaging technique for extending the shelf-life of food products. J Inst Sci Technol. 2019;9(4):2117-2123.

[18] Punfujinda C, Pattarathitiwat P, Saree M, Songpranam P, Atthatham A, Yimtoe C, Chumkaew K. Effect of corn starch on sensory quality, physical quality, and consumer acceptance of gelatin-free pudding products. Asia Pac J Sci Technol. 2024;29(5).

[19] Punfujinda C, Pattarathitiwat P, Boukaew S, Chumkaew K. Effects of Thai pigmented rice (Riceberry and Hom Nil; *Oryza sativa* L.) flours on quality of kanom piak poon (traditional Thai dessert). Int Food Res J. 2025;32(1):92–107.

[20] Shapiro R. Nutrition labeling handbook. New York (USA): Marcel Dekker, Inc; 1995.

[21] AOAC. Official methods of analysis of AOAC international. 21st ed. Maryland, USA. 2019.

[22] ISO. Dried skimmed milk determination of vitamin A content. Part 2: Method using high-performance liquid chromatography (ISO 12080-2:2000(E)). Geneva (Switzerland): International Organization for Standardization; 2000.

[23] Kemsawasd V, Chaikham P. Effects of frozen storage on viability of probiotics and antioxidant capacities of synbiotic riceberry and sesame-riceberry milk ice creams. Curr Res Nutr Food Sci J. 2020;8(1):107-121.

[24] Dowarah L, Bhowmick DR, Chakraborty S. Fast food consumption behaviour among college Students-A case study in Tinsukia. Curr. Res Nutr Food Sci J. 2020;8(2):371-379.

[25] Bukhari F, Hussain S, Ahmed RR, Mubasher KA, Naseem MR, Rizwanullah M, Nasir F, Ahmed F. Consumers' purchase decision in the context of western imported food products: Empirical evidence from Pakistan. Heliyon. 2023;9(10): e20358.

[26] Singhato A, Banjong O, Charoonruk G. Effectiveness and acceptance of the developed educational media on the application of a Thai ethnic snack, Thong Pub, with calcium fortification. J Ethn Foods 2017;4(1):58-63.

[27] Mit Samphan Group Community Enterprise. Financial Report of Mitr Samphan Group Community Enterprises. Chachoengsao (Thailand): Mit Samphan Group Community Enterprise; 2024.
[28] Bureau of Nutrition, Department of Health. Healthy Meeting. Bangkok (Thailand): Love Job Production; 2019.
[29] ThaiHealth Official. Organize healthy snacks. Thai Health Promotion Foundation. 2015.
[30] Chatsaha N. Food labels. Food and drug administration Thailand. 2012.
[31] Silva de Paula N, Gomes Natal DI, Ferreira HA, de Souza Dantas MI, Machado Rocha Ribeiro S, Stampini Duarte Martino H. Characterization of cereal bars enriched with dietary fiber and omega 3. Rev Chil Nutr. 2013;40(3):269-273.
[32] Cortina-Mercado M. Effect of packaging design in the purchase decision process: a comparison of generations. Glob J Bus Res. 2017;11(2):11-26.
[33] Srebernich SM, Gonçalves GMS, Ormenese RDCSC, Ruffi CRG. Physico-chemical, sensory and nutritional characteristics of cereal bars with addition of acacia gum, inulin and sorbitol. Food Sci Technol. 2016;36(3):555-562.
[34] de Arruda LC, Faria WCS, Siqueira NFMP, de Sousa Campos MF, de Barros WM. Development of cereal bar with baru almonds and pineaplle peels. Res Soc Dev. 2021;10(5):1-12.
[35] Van Meerkerk I, Kleinhans R, Molenveld A. Exploring the durability of community enterprises: A qualitative comparative analysis. Public Adm. 2018;96(4):651-667.