into these products [2].

A food bar item commonly found in Thailand, referred to as "Krayasart", is made by combining sugar cane juice, coconut milk, glucose syrup, and various ingredients such as peanut, popped rice, roasted ground rice, and white sesame. Once mixed, it is cut into small bars and wrapped in banana leaves. This product is sticky and has a high sweetness value, traditionally prepared for Buddhist religious events. However, its consumption has decreased due to its characteristics. In response, various developments have been made, including the addition of herbs, brown rice, germinated rice, and bioactive constituents to improve its nutritional value [3]. Thus, future studies should focus on improving the texture, sweetness, and health benefits.

Banana (*Musa* spp.) is a tropical fruit, one of the leading food suppliers in the world. Banana flour is made from the unripe banana stage. Native starch provides gluten-free, resistant starch (40.9-58.5%) and dietary fiber (6.0-15.5%) [4]. Furthermore, Hom thong banana variety has a low glycemic index (GI), which is essential for supporting the digestive system [5]. However, there are limited usages of native starch because of its low solubility and swelling properties [6]. The pregelatinized technique is a common pre-cooking method. The native starch is the first state in a semi-crystalline, but the structure is degraded by cooking in water and accomplishes the starch. After drying using drum drying, it is more soluble and swellable. Thus, modified starch is more suitable for various products, such as food bars, ice cream and bakery applications [7].

The plant species known as Pumpkin (*Cucurbita maxima*) is becoming increasingly popular for its numerous nutraceutical and therapeutic benefits. Its seed oil contains dominant fatty acids, including linoleic, oleic, stearic, and palmitic, which comprise 95% of the total fatty acids, with 75% being unsaturated fatty acids (UFAs) [8]. Research has shown that consuming pumpkin products can help protect against cardiovascular diseases and support the brain and nervous system [9][10]. Traditionally, we tend to consume it as a roasted and salted snack. Furthermore, recent studies have suggested that pumpkin seeds can be used as a functional food ingredient in various food development [11][12].

The characterized traditional Thai food bars have limitations. It might be possible to improve the product by incorporating banana flour and alternative sweeteners, reducing stirring time, and using mild temperatures to initiate a soft texture. Additionally, incorporating pumpkin seeds could enhance the nutritional value of food bars. However, more information must be provided regarding their properties when used in this context. The study will incorporate these ingredients and evaluate their effect on food attributes and perceptions. The outcomes of this research will have implications for process practical and community entrepreneurs to develop functional food bars.

2. Materials and Methods

2.1. Banana Flour Modification

Commercial unripe green banana (Hom thong variety) was received from Bioform International Co., Ltd. (Bangkok, Thailand). After washing, it was cut into 1.0-1.5 cm thicknesses and tray-dried at 60 ℃ for 48-54 hours until the water content was below 8%. The dried banana flour (DBF) was ground into powder (size≤60 mesh) using a Fitz mill (CTC8, CTC Co., Ltd, Samut Sakorn, Thailand) and kept in LLDPE bags at room temperature. Besides, pregelatinized banana flour (PBF) was modified. The raw DBF to distilled water ratio was 1:5% (w/v), and it was melted into hot water at 85-90 ℃ using a double pot until completely dissolved. The PBF was dried by a drum dryer (TDD300, PSA21 Part., Ltd, Pathum Thani, Thailand) at 140 ℃, with a 50 mm gap distance between the rollers and a speed of 0.45 rpm. The PBF properties were analyzed using a differential scanning calorimeter (DSC1/400W Mettler Toledo, Japan). Additionally, the pasting profiles were measured using a rapid visco analyzer (TechMaster, Perten Instruments, Sweden), and the peak viscosity (PV), final viscosity (FV), setback viscosity (SBV), and pasting temperature (PT) were recorded. In addition, water absorption index (WAI) and water solubility index (WSI) were measured. A certain amount weight of flour was initially placed in a centrifuge tube. Subsequently, 15.0 ml of distilled water was added. The mixture was placed in a water bath at 30 ℃ for 30 min with a magnetic stirrer. Subsequently, the tube was centrifuged at 3,000 rpm for 10 min. The resulting clear water was transferred into a moisture can and dried in a hot air oven at 100 ℃ until completely dry. The water solubility index (WSI) refers to the weight of soluble flour per initial weight, while the water absorption index (WAI) is the weight of sediment weight per initial weight. WAI was calculated as grams of gel obtained per gram of solid.

$$\text{WAI} = \frac{\text{weight of sediment}}{\text{weight of dry solid}} \quad (1)$$

$$\text{WSI (\%)} = \frac{\text{weight of dissolved solid in supernatant}}{\text{weight of dry solids}} \times 100 \quad (2)$$

2.2. Preparation of Traditional Food Bars (TFB)

Sugar cane syrup, coconut milk, glucose syrup, roasted ground rice, popped rice, peanut and white sesame were purchased from a supermarket in Prathum Thani, Thailand, and food-grade erythritol (Chemipan Co., Ltd., Bangkok, Thailand) was used. All ingredients were kept in a dried condition. Sugar cane syrup was heated to 60 ℃, and then coconut milk and glucose syrup were added. After that, it was constantly stirred until the ingredients became sticky. Roasted ground rice, popped rice, peanut and white sesame were added and stirred until finalized mixed at 80 ℃. Different stirring times at 50, 60 and 70 min were used. A

completely randomized design (CRD) was applied. After cooling, it was cut into pieces (3 cm wide x 10 cm length x 1.5 cm thickness) and packed into linear low-density polyethylene (LLDPE) bags and stored at room temperature. The properties and sensory evaluation were analyzed.

The water activity (a_w) was measured using an Aqualab (CX4TE, Meter, WA, USA). The HDP/BSK probe of the texture analyzer (TA-XTPlus, Texture Technologies and Stable Micro Systems, CO., Ltd., MA, USA) was applied using parameters: pre-test at 1.0 mm/s, and post-test speed at 10 mm/s, and compression distance at 30 mm. Hardness (g) was reported as the average maximum peak force.

For the sensory evaluation of the color, odor, sweetness, stickiness and overall acceptance of the TFB, A 9-point hedonic scale ranging from 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely was evaluated. Untrained panel (30 panelists, of which 12 were males and 18 were females) who ranged from 18 to 25 years of age, with experience in consuming samples and no allergen limitation, were tested. Each sample was presented with three-digit random number samples in a random presentation order.

2.3. Development of Functional Food Bars (FFB)

2.3.1. Functional Food Bars Formulation

The preliminary study registered that 50% of sugar cane syrup in TFB formulation could be replaced by erythritol 1.5% (w/w). The study used banana flours at 1.0, 3.0, and 5.0% (w/w), which varied on 2^3 factorials in a completely randomized design (CRD). The samples were analyzed by the texture analyzer (TA-XT Plus) and a_w by a water activity (Aqualab) meter for selected a TTB formulation.

2.3.2. Consumer's Perceptions of FFB

Pumpkin seeds (PS) at 2.5 and 5.0% (w/w) were fortified in FFB. A completely randomized design (CRD) was used. Sensory evaluation was examined. A total of 100 untrained testers (47 men and 53 women) who had between 18-50 years of age were recruited from students and staffs of the Faculty of Science and Technology, Rajamangala University of Technology Thanyaburi, Pathum Thani, Thailand. Samples were presented with three-digit random number samples in a random presentation order. Allergic information was presented before testing. The attributes of color, hardness, sweetness, aroma, stickiness and overall acceptance were tested using a hedonic scoring 9-point scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely).

To screen for product-related emotion, FFB was served to measure self-reported emotions using a check-all-that-apply (CATA) scale comprising 22 emotion terms (happy, healthy, calm, pleasant, satisfied, good, enjoyable, active, interested, nurturing, guilty, regret, sad, worried, disgusted, neutral, bored, hate, unpleasant, comforting, contentment, and anxiety) [13][14][15]. The participants were provided with bars along with health information. The percentage of emotions selected by >10% of respondents was reported within undergraduate and graduate. Health messages were followed.

1. Contains 10-15% protein, which can enhance muscle mass, metabolism, and provide energy
2. Contains only 2 g of sugar, resulting in less sugar entry
3. It contains pumpkin seeds, which are super-seeds rich in unsaturated fatty acids, and protein.
4. No artificial colors or flavors are used

2.3.3. Nutrition Determination of Functional Food Bars

Nutrition properties were determined by analyzing the proximate compositions, including total fat, total sugars, protein, and total carbohydrates, applied by AOAC (2000). The National Food Institute in Bangkok, Thailand approved the sodium content. The nutrition was calculated and reported per 100 g of sample.

2.4. Statistics Analysis

The study employed an Analysis of Variance (ANOVA) to identify variations in the means. The SPSS 17.0 software (SPSS Inc., IL, USA) was utilized. Statistical significance ($P \leq 0.05$) was established.

3. Results and Discussion

3.1. Characteristics of Modified Banana Flour

The thermodynamic characteristics of various flours are displayed in Table 1. The findings indicate that DBF exhibited distinct onset, peak, and enthalpy values, which were 73.59 ℃, 80.35 ℃, and 14.55 J/g, respectively. These values were significantly different ($P \leq 0.05$) from those of PBF, which recorded values of 70.64 ℃, 77.29 ℃, and 10.08 J/g, respectively. Hence, flour that had been modified using the drum drying technique demonstrated superior attributes relative to the DBF. Therefore, using modified banana flour in combination with mild temperature may cause food bars to improve their texture.

Table 1. Thermodynamic properties of banana flours by DSC analysis

Flour Sample	Thermodynamic properties*		
	On set (℃)	Peak set (℃)	Enthalpy (J/g)
Dried banana flour (DBF)	73.59±0.38[a]	80.35±0.22[a]	14.55±0.27[a]
Pre-gelatinized banana flour (PBF)	70.64±0.58[b]	77.29±0.07[b]	10.08±0.04[b]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

Table 2. Pasting properties of banana flours by RVA analysis

Flour Sample	Pasting properties*			
	Pasting Parameter (RVA)			Pasting temperature (℃)
	Peak Viscosity	Final Viscosity	Setback	
Dried banana flour (DBF)	936±0.48[a]	1228±0.24[a]	443±0.18[a]	85.35±0.25[a]
Pre-gelatinized banana flour (PBF)	730±0.42[b]	813±0.15[b]	103±0.35[b]	53.35±0.24[b]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

Table 2 presents the pasting properties of various flours, with findings indicating that their pasting temperatures ranged from 53.35±0.24 ℃ to 85.35±0.24 ℃. Additionally, it was observed that the final viscosity of PBF was 1.5 times greater than that of the DBF. These results suggest that PBF is more malleable at lower pasting temperatures than the DBF ($P \leq 0.05$) and is therefore better suited for producing food bars with the desired properties using less energy. Several studies have indicated that PBF has lower enthalpy values than DBF, resulting in a reduced energy requirement for gelatinization [16][17]. This study illustrated that the pasting properties of pre-gelatinized starch decreased. Pre-gelatinized starch (PBF) exhibits a lower value of peak viscosity, final viscosity, and setback viscosity than DBF which was in accordance with Kananurux & Thongngam, (2009) and Kongolo et al., (2017) [18][19].

As depicted in Table 3, the water capacity refers to a PBF to interacts with water, which impacts the ease of flour homogenization when combined with water. The modified flour demonstrated increased water solubility and absorption ($P \leq 0.05$) and the high-water capacity of PBF utilized as an ingredient in FFB formulations [20].

Table 3. Physicochemical properties of banana flour

Flour Sample	Physicochemical properties*	
	water solubility index	water absorption index
Dried banana flour (DBF)	14.55±0.73[a]	6.15±0.17[a]
Pre-gelatinized banana flour (PBF)	17.27±1.14[b]	7.88±0.54[b]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

3.2. Effects of Processing Time on Traditional Food Bars properties

The samples of stirring time were collected from 50, 60, and 70 min. The results included that the qualities of TFB differentiated depending on processing time, including hardness and a_w. The hardness ranged from 12,274.50±257.32 g to 15,892.15±309.10 g, with a statistically different ($P \leq 0.05$). On the other hand, a_w varied between 0.63-0.66, presented in Table 4. This study supported that water loss might make the texture harder with a longer stirring time, which had a more rigid texture but lower a_w values.

Table 4. The traditional food bar's physical properties

Stirring time (min)	Physical Properties*	
	Hardness (g)	a_w
50	12,274.50+257.32[c]	0.66+0.01[a]
60	14,313.56+280.15[b]	0.65+0.01[a]
70	15,892.15+309.10[a]	0.63+0.01[b]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

The results of the sensory evaluation in Table 5 revealed that stirring the food bars for 60 min produced desirable attributes, such as overall quality ($P \leq 0.05$), compared to 50 and 70 min (6.70 vs. 5.69-6.62 from 9 points). Additionally, 60 min showed higher scoring of texture comparable to those achieved at 50 and 70 min. While color scored 6.62-6.75, and odor levels 6.42-6.50 showed no difference ($P > 0.05$). Therefore, 60 min of stirring time provided slightly like to moderately like by hedonic acceptance, linked to the medium hardness values compared to 50 and 70 min in Table 4. Based on the results, the optimal stirring time is 60 min due to the desired hardness and preferred sensory attributes.

However, longer stirring times cause moisture migration between different carbohydrates, leading to increased hardness of the food bars while also reducing moisture content, which can enhance shelf-life and maintain a crispy-sticky texture [21]. Moreover, raising the stirring temperature can affect the texture of the snack bars, with

higher temperatures and longer times leading to better ingredient gelatinization and increased syrup viscosity, resulting in hard texture [22] and better protein quality [23].

Table 5. Sensory evaluation of the traditional food bars

Stirring time)min)	Attributes*		
	Sweetness	Stickiness	Overall acceptance
50	6.48 ±1.66[a]	4.62 ±1.66[b]	5.69 ±1.38[b]
60	6.23 ±1.69[b]	6.15 ±1.52[a]	6.**70** ±1.50[a]
70	6.15 ±1.77[b]	5.69 ±1.46[a]	6.62 ±1.50[a]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

3.3. Development of Functional Food Bars (FFB)

3.3.1. Banana Flour in FFB Formulations

The findings of the data analysis revealed that both the type of banana flour and the varying concentrations used had a significant impact on the hardness and a_w ($P \leq 0.05$). The results demonstrated that food bars fortified with PBF were less hard than those fortified with native starch at the same concentration, while there was no significant difference in a_w. Additionally, the type of flour had a statistically significant ($P \leq 0.05$) effect on the hardness, while the concentration and combined effect did not significantly impact hardness. Consequently, incorporating PBF may lead to a decrease in the hardness.

Table 6 provides information on the a_w values, indicating the free water content of microorganisms used. The data revealed that the concentration of flour had a significant impact on their properties. Specifically, it was found that fortified native flour with a concentration of 5.00% (w/w) had lower aw values compared to PBF ($P \leq 0.05$). Moreover, banana flour affected the texture of the food bars. The use of FFB led to a decrease in a_w values as the concentration increased. The study also found that food bars fortified with these flours at concentrations of 1.0-3.0% (w/w) had a hardness value similar to that of the TFB in Table 4. Furthermore, PBF provides a softer texture than DBF. Consequently, PBF at 3.0% (w/w) in the formulation was selected for FFB formulation.

Banana flour is a valuable source of resistant starch [24] and nutrients, including proteins, carbohydrates, dietary fiber, vitamins, minerals, and polyphenols with antioxidant properties [25]. It is frequently used as an ingredient to enhance the texture of various food products [26][27] [28], such as pasta, macaroni, food bars, and brownies [29][30]. Studies have shown that green banana flour exhibits superior paste stability during mechanical processing compared to corn starch, attributed to its lower consistency and setback values [31]. Thus, fortifying green banana flour can improve its properties. The impact of green banana flour on the hardness of cooked spaghetti is insignificant, even when substituting 15-45% of native banana flour [32]. Additionally, the amount of flour used significantly affects the final hardness of food bars, with banana peel powder increasing the complexity and factorability of snack bars [33]. The high fiber content of powdered bananas improves snack hardness [34] and water activity, indicating high microbial spoilage resistance.

According to Table 4 and 6, it is promising using modified banana flour at a mild temperature may cause PBF to have a reduced level of texture. In addition, using sweeteners by reducing the amount of sugar cane syrup may result in reduced stirring time. It contributes to a softer texture.

Table 6. The physical qualities of functional food bars using different banana flours

Flour Sample	Concentration %(w/w)	Properties*	
		Hardness (g)	a_w
Dried banana flour (DBF)	1.0	12,830.08±270.15[c]	0.65±0.02[a]
	3.0	14,903.26±220.20[b]	0.63±0.01[a]
	5.0	17,938.15±289.25[a]	0.61±0.01[b]
Pre-gelatinized banana flour (PBF)	1.0	11,513.56±280.15[c]	0.65±0.01[a]
	3.0	13,692.15±309.10[b]	0.64±0.01[a]
	5.0	16,908.11c±219.55[a]	0.62±0.01[b]

*Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

Table 7. Sensory evaluation of functional food bars with different pumpkin seed concentrations

Sample**	Attributes*			
	Hardness	**Sweetness**	**Stickiness**	**Overall acceptance**
FFB without PS	6.96 ± 1.72^{a}	6.89 ± 1.76^{b}	6.44 ± 1.78^{a}	7.15 ± 1.46^{b}
FFB +2.5% PS	6.88 ± 1.85^{a}	7.11 ± 1.18^{a}	6.74 ± 1.99^{a}	7.52 ± 1.42^{a}
FFB +5.0% PS	5.27 ± 2.10^{b}	7.03 ± 1.40^{b}	5.21 ± 2.31^{b}	6.62 ± 1.40^{c}

* Shown mean±standard deviation and different small letters among columns represent significantly different ($P \leq 0.05$)

**Pumpkin seeds = PS

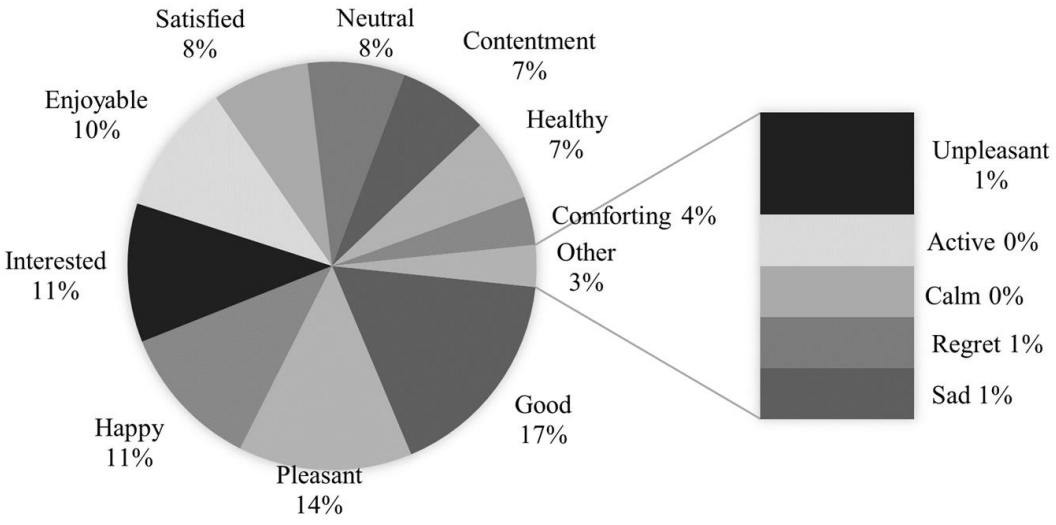
Table 7 presents the sensory evaluation of functional food bars containing PS. A nine-point hedonic scale was employed to assess the perception of three different formulas. The results indicate that the attributes of the food bars varied significantly ($P \leq 0.05$), while the PS different levels did not significantly affect the color ($P > 0.05$). However, the incorporation of 2.5% (w/w) of PS was the most preferred by the panelists compared to the other formulations. The FFB with 2.5% (w/w) PS received higher ratings for preferred sweetness, hardness, sticking in teeth, and overall acceptance, with scores of 7.11 ± 1.85, 6.88 ± 1.85, 6.74 ± 1.99, and 7.52 ± 1.42, respectively, compared to the TFB formulation as presented in Table 4. Previous studies indicate that the phenolic acids present in green banana flour can impact the length of the external starch chain, leading to interactions in both the amorphous and crystalline lamellae of starch granules. This interaction results in decreased hydration of amylopectin, leading to reduced pasting viscosities of starch [35]. Modified banana flour with reduced pasting properties also exhibits high thermal stability and a lower tendency to retrogradation, which enhances its stability during storage. Fortifying the cooked flour of this product can further reduce retrogradation capability and prolong the stability of its properties. The lower pasting properties of this flour can improve the mouthfeel during consumption [36]. Previous studies indicate that the presence of phenolic acids in green banana flour can impact the length of external starch chains and induce interactions in the amorphous and crystalline layers of starch granules. This interaction leads to a decrease in the hydration of amylopectin which results in reduced pasting viscosities of starch. The use of modified banana flour with reduced pasting properties also results in enhanced thermal stability and a decreased tendency toward retrogradation [37]. When applied to cooked flour, this fortification leads to a longer shelf life and better stability of properties during storage. Additionally, low pasting properties can improve the mouthfeel of products during consumption [38].

Incorporating PS resulted in a reduction in their sweetness and crispiness, which can be explained by the presence of a significant amount of fiber in PS. This fiber can absorb moisture, resulting in a less sweet and crispy outcome. Additionally, the texture of PS can also affect the overall texture of the snack bar.

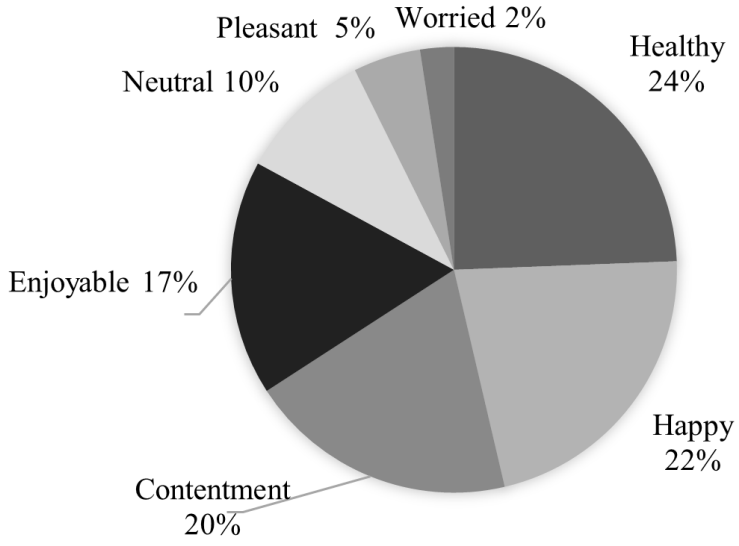
3.3.2. Consumer's Perceptions of FFB

The emotional response of customers to FFB was investigated by CATA, revealing that adolescents who tasted the product reported positive emotions such as feeling good, pleasant, happy, interested, and enjoyable. The study also found that 62% of the customers intended to purchase the product. Graduated customers reported feeling healthy, happy, content, and enjoyable, with 24%, 22%, 20%, and 17% respectively, and 72% of these testers had the intention to purchase the product (Figure 1). The middle-aged group was more likely to feel healthy, while the younger group experienced strong emotions of enjoyment and feeling good. The overall positive emotion reported ranged from 64-83%. These findings demonstrate the emotional impact of FFB on customers and may inform marketing strategies.

The previous study suggested that taste and flavor are essential in purchasing snack foods related to health claims. [39]. Based on consumer feedback following taste tests, participants reported experiencing positive emotions such as "healthiness," "happiness," "pleasure," "interest," "enjoyment," and "contentment." These positive emotions are likely to boost consumers' intentions to purchase. The outcomes of the CATA approach for functional food bars indicated that older individuals exhibit a higher level of interest in healthy snack bars compared to younger individuals. This may be attributed to older adults' heightened awareness of the significance of maintaining a balanced diet and the impact of nutrition on their overall health [40]. In contrast, individuals in younger age groups may place greater importance on taste and convenience when selecting snacks due to their busy lifestyles and differing priorities. Furthermore, they may be more vulnerable to marketing messages that prioritize taste and convenience over nutritional value. As individuals age, they tend to prioritize positive emotions more highly, with older individuals reporting greater satisfaction after consuming healthy foods they prefer. Studies have identified associations between flavours and emotions.



(a)



(b)

Figure 1. Frequency (%) of emotion perception after getting information and testing functional food bars: (a) undergraduate group, (b) graduated group

3.3.3. Nutrition Determination of FFB

The results presented in Table 8 indicate that FFB fortified PS had a proximate composition of 2.5% (w/w) compared to TFB. This finding suggests that incorporating PS into food bars can improve their nutrition contents, while simultaneously reducing their total calorie, sugar, and carbohydrate content. Specifically, FFB had a reduced total calorie content of 386 Kcal/100g, and a higher nutritional value due to the increased protein content of 16.2 g/100g in TFB information resulting from the addition of PS. Additionally, the sodium content was found to be 35 mg/100g. Overall, the substitution of sugar cane juice with PBF and PS offers potential nutritional benefits.

Table 8. The nutrition values of food bars

Sample	Values				
	Total Calories Kcal/100g	**Total fat g/100g**	**Total sugar g/100g**	**Total carbohydrate g/100g**	**Protein g/100g**
TFB	496	25.7	20.0	51.1	15.2
FFB	386	25.7	17.4	48.5	16.2

The report [41] proposes that taste and flavour are crucial factors that influence consumers' food purchasing decisions. The combination of modified banana flour and pumpkin seeds is known to enhance the functional properties of food, which influences consumers' perceptions and evokes positive emotions due to the presence of bioactive ingredients. The findings of the study support the development of functional food products by traditional Thai food bars that align with consumers' trends and preferences.

4. Conclusions

The modified banana flour using drum drying has superior qualities to native banana flour. The hardness, a_w, and sensory acceptance were assessed after stirring the TFB for 60 min. The type of banana flour used affected the hardness while adding modified starch reduced hardness. Adding 2.5% (w/w) of PS to the FFB resulted in the most positively perceived product by panelists, with a slight preference for sweetness, hardness, stickiness, and overall acceptance. Emotion testing, including healthiness happiness, pleasure, interest, enjoyment, and contentment indicated that consumers favored the addition of PS to food bars, which could meet future food trends and have high purchase intent among the two assessors. The FFB had a reduced total calorie content of 386 Kcal/100g, but its nutritional value improved with an increased protein content of 16.2 g/100g due to the addition of PS. The sodium content was also low at 35 mg/100g. This product has the potential as a functional food bar. Thus, implications for practice, it used to monitor the food properties and sensory perception, and communities applied to develop alternative food bars, to meet the needs of consumers.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publications.

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