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Food Science



DEVELOPMENT OF PLANT-BASED CREAM CHEESE SPREAD

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Abstract

The purpose of this research was to develop a new plant-based cream cheese spread and study the target consumer acceptance through sensory evaluation. The soya cheese was coagulated by citric acid and vegetarian rennet. This cheese was then used to develop new plant-based cream cheese spread. The plant-based cream cheese spread consisted of 75 g soya cheese, 2 g oregano, 2 g ground garlic, 4 g salt and 2 g pepper powder. The influence of plant-based yogurts, including, coconut yogurt, almond yogurt and soya yogurt on sensory evaluation, namely the 9-point hedonic scale, just about right and acceptance tests was investigated.

The findings revealed that the plant-based spread mixed with soya yogurt had the highest preference score amongst three spreads. The combination of coconut yogurt and almond yogurt in cream cheese spread led to the lower liking score in creaminess, sourness, sweetness and flavor. Thus, the spread mixed with soya yogurt was selected to develop by adjusting the salt and soya yogurt contents. This developed plant-based cream cheese spread provided a higher liking score in all attributes than those in the previous formula, including color (7.02±1.05), creaminess (6.63±0.32), softness (6.57±0.54), saltiness (6.37±0.26), sourness (6.45±0.26), sweetness (6.44±1.31), oiliness (6.37±0.89), flavor (6.10±0.67), spreadability (6.00±0.20) and overall liking (6.84±0.91). In addition, 81% of the respondents accepted this product, and 76% decided to purchase it for the main reasons of taste (30%), plant-based product (21%), new product (20%), and texture (15%).

Keywords: Plant-Based Cheese, Plant-Based Cream Cheese Spread, Spread, Soy and Sensory Attributes

Introduction

Cream cheese spread is typically made with cream cheese as the base, which is then softened and mixed with other ingredients to create a variety of flavors. Cream cheese spread is a creamy white that is widely consumed with crackers, bagels, vegetables, or even as a dip or filling. The coagulation of cream or a mixture of milk and cream by acidification with starter cultures (namely, *Lactococcus* and *Leuconostoc*) is generally used to produce the cream cheese spread (Phadungath, 2003). This spread is a soft, mild and unripened cheese, which should be spreadable whether at room temperature (25°C) or cold temperature (7.2°C), according to the USDA (1994). The essential attribute of cream cheese is spreadability, which is the textural property performed by hand (Bredinger and Steffe, 2001). However, dairy cream cheese spreads are high in saturated fat, salt and calories. The dairy cheese spreads also consist of lactose, which directly affect the people with lactose intolerance or people with dairy milk allergies (Dobson et al., 2022). Therefore, the concept of healthy plant-based cream cheese with low fat and calories is raised in this study.

The plant-based trend whether in Thailand or internationally has been growing in recent years due to health awareness, environmental well-being, sustainable foods, animal welfare and the reduction of meat consumption in the daily diet (Samard et al., 2019). Plant-based food is a diet or

food product, that is basically made or derived from plant-based ingredients such as fruits, vegetables, whole grains, legumes (beans, lentils and peas), nuts, seeds, mushrooms and oils. Plant-based food refers to food without animal ingredients or food that includes a minimal amount of animal ingredients. Recently, the development of plant-based cheese or cream cheese spread has been gaining attention from both academic and industry sectors. For example, the US sales of plant-based cheese have increased by 70%, with reported US sales of 270 million in 2020 (GFI, 2022). This increase might be due to the growing number of individuals with dairy allergies, societal acceptance, and competitive pricing (Dobson et al., 2022). The main categories in the plant-based cheese sector include nut-based products, plant-based milk alternatives, and starch and oil-based cheese (Saraco, 2021; Short et al., 2021). The ingredients used in these products have a significantly lower environmental impact, creating less than 2.5 kg of CO₂/kg of product (Ritchie et al., 2022). Thus, in this study, the soya milk is used to manufacture plant-based cheese because the soya bean (soybean) provides high-quality protein, source of fiber, healthy fats, low calories, essential vitamins and minerals. Moreover, soya beans are versatile, affordable and provide a neutral flavor with a familiar taste. Plant-based yogurts, including, coconut yogurt, almond yogurt and soy yogurt, are one of the cream cheese ingredients used as minor portion in this study, in order to thicken the culture process and increase the acidity and flavor of the yogurt.

Therefore, the aims of this research are to develop a new plant-based cream cheese spread to fit the target consumer needs, which mainly produce plant-based cheese (soya cheese) as a base, and to make the process the same as for regular cream cheese spreads. The dairy-free alternative ingredients, namely, plant-based yogurts (coconut yogurt, almond yogurt and soya yogurt), spices and seasoning are utilized in the spread samples. The sensory evaluation, including, consumer liking and acceptance of plant-based cream cheese spread is investigated.

Research Objectives

1. To develop a new plant-based cream cheese spread from soya cheese
2. To study the sensory evaluation of a new plant-based cream cheese spread with different plant-based yogurts
3. To investigate the consumer acceptance of a developed plant-based cream cheese spread

Literature Review

1. Plant-based food

Plant-based foods generally include fruits, vegetables, nuts, seeds, oils, whole grains, legumes, and beans. The increasing of plant-based foods can be attributed to various concerns such as health, sustainability and animal welfare. In terms of conventional production of dairy, there are three major areas of concern: environment impact (emissions of greenhouse gases, pollution of soil and water, and land use), human health (exposure to zoonotic diseases and increased antibiotic resistance), and animal welfare (treatment of farmed animals, including disease, injury, and mental/emotional well-being) (Clay et al., 2020). Moreover, plant-based foods are a good source of protein with the advantage of being low in fat, a source of fiber, and numerous valuable phytonutrients (high biological value), all of which are lacking in animal-based foods (McMacken and Shah, 2017).

2. Plant-based cream cheese spread

Dairy cream cheese spread or spreadable is generally a processed cheese adaptable to the fast-food trade and widely consumed worldwide as a spread or as an ingredient in a variety of cold-prepared foods. The disadvantage of the dairy cream cheese is a high fat content (280 g/kg) and its



high calories and salt (USDA, 2019). Therefore, the production of plant-based spreadable cheese with better nutritional properties than the conventional dairy one is a challenge. Currently, there are two general approaches producing plant-based cream cheese, according to the research of Short et al. (2021). One concept is the intention to mimic the sensory attributes of conventional dairy cheese spread, while another idea is the purpose of creating the unique flavors and characteristics derived from the plant. The challenge is that plant-based ingredients do not precisely mimic the sensory attributes (flavor, taste, texture and aroma) and physical characteristics (mouthfeel and meltability) of dairy-based cheese which limits consumer acceptability. Consequently, the development of plant-based cheese involves the use of fat and/or protein sources other than those native to milk, together with a flavor system simulating as closely as possible that of the natural product. Previous studies have focused on spreadable soy-based products that are coagulated by enzymes, salts, or acids (Jeevanthi and Paik, 2018; Li et al., 2013). The type of coagulants used in curdling soy cheese affects the shelf life, nutritional composition, sensory quality, and quantity of cheese spread.

3. Soya bean (Soybean)

Soya bean or soybean, is a species of legume native to East Asia and is a popular choice for producing meat analogue due to its characteristics such as high-quality protein, a good balance of amino acids, desirable fatty acids, low calories, essential vitamins and minerals. Soya milk has nearly the same nutritional proportions as cow milk, including 3.5% protein, 2% fat, 2.9% carbohydrate and 0.5% ash (Raja et al., 2014). Soy-based foods have obtained beneficial health claims such as hypolipidemic, anticholesterolemic, and antiatherogenic properties, as well as reduced allergenicity (Jeevanthi and Paik, 2018). The study of Lim et al. (2011) reported that the combinations of hard tofu, 5% of palm oil w/w, and 3% of NaCl w/w resulted in a better firmer textured spread, whereas the research of Rinaldoni et al. (2014) developed the soya creamy spread by using ultra-filtrated (UF) and freeze-dried soy flour in order to improve nutrients.

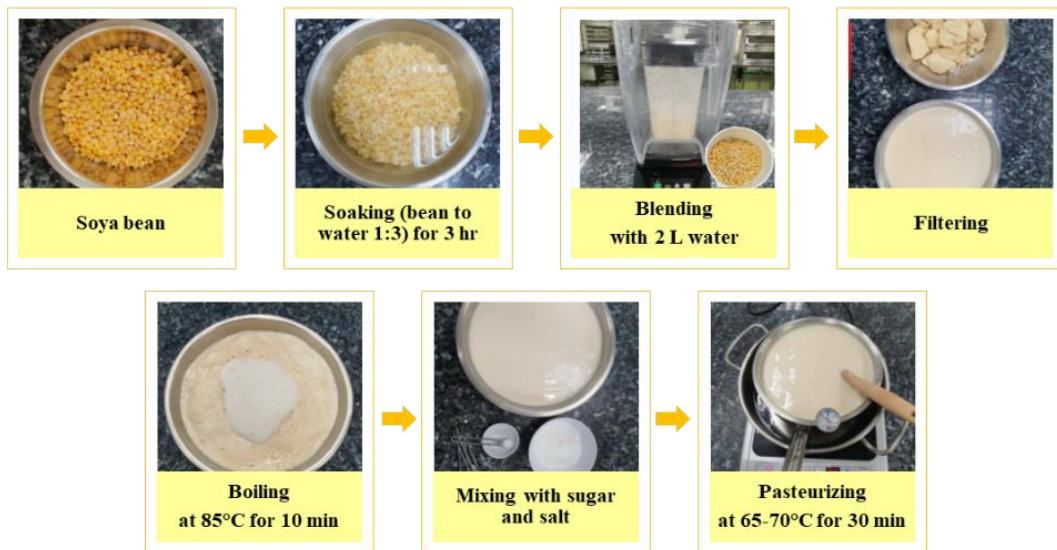
4. Plant-based yogurt

Plant-based yogurt is a yogurt made from plant-based milk instead of dairy. It is a great alternative for people who are vegan, lactose-intolerant, or simply looking for a dairy-free option. These yogurts are typically made from nuts (almonds, cashews and coconuts), legumes (soy), grains (oats), or even fruits (plantains). General yogurt is fermented by two types of yogurt bacteria. The *Lactobacillus bulgaricus* ferments the sugar in milk to provide tangy flavor, while the *Streptococcus thermophilus* creates a favorable environment for *Lactobacillus* and produces an antimicrobial compound. Plant-based yogurt offers several benefits when making soya cheese spread. Giri et al. (2018) described that the soya milk naturally lacked the creaminess of dairy milk, which led to light creamy spread. Thus, the incorporation of yogurt helped to contribute a creamy texture to the spread. Additionally, the tanginess from the yogurt fermentation enhanced a flavor dimension similar to dairy cheeses.

Methodology

1. Preparation of pasteurized soya milk

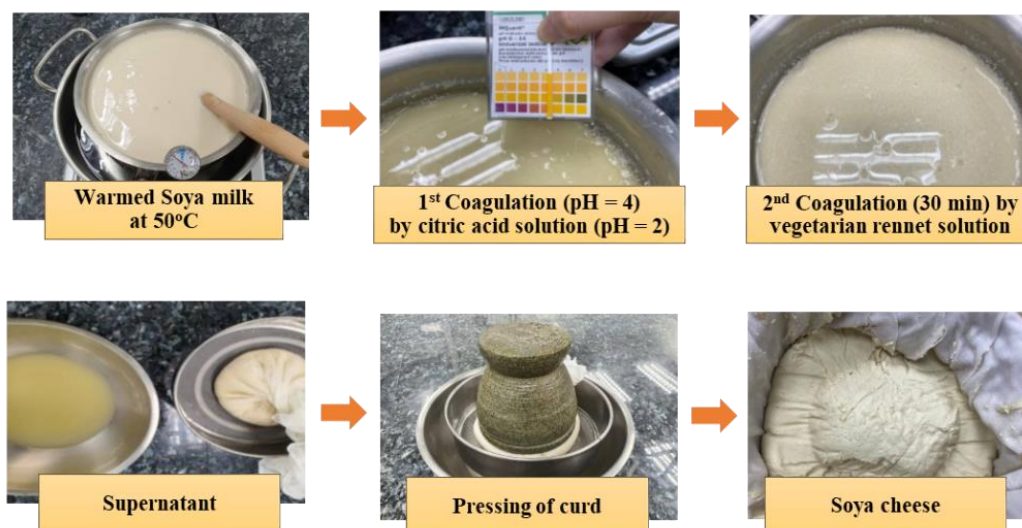
The pasteurized soya milk production was displayed in Picture 1. Soya bean (soybean) was washed and soaked in boiled water at a 1:3 ratio at room temperature for 3 hr. Then, the soaked soya bean was drained and blended with 2 L cleaned water. The soya liquid was strained through a filter cloth to extract the soya milk. After that, the soya milk was boiled at 85°C for 10 min in order to remove the unpleasant odor and beany flavor. The boiled soya milk was mixed with 100 g sugar and 3 g salt, and followed by pasteurization at 65-70°C for 30 min.



Picture 1: The production of pasteurized soya milk

2. Process of soya cheese production

The coagulation of pasteurized soya milk was carried out by citric acid and vegetarian rennet, according to the procedure of Ikyaj et al. (2019) with slight modification as shown in **Picture 2**. The citric acid solution (pH 2.0) was prepared by putting 9 g of citric acid powder in 150 ml of cleaned water, while the 0.2 g vegetarian rennet was dissolved in the cleaned water. The citric acid solution was first put into warmed soya milk at 50°C until pH 4.0. The rennet solution was then added and the soya cheese was left to form curd for 30 min. Soya cheese was separated out of the supernatant (soy protein liquid) by filter cloth and the mortar.



Picture 2: The production of soya cheese

3. Development of new plant-based cream cheese spread

The development of new plant-based cream cheese spreads was mainly manufactured by soya cheese and plant-based yogurts. There were three different plant-based cream cheese spreads (PBCCS), including PBCCS-coconut yogurt, PBCCS-almond yogurt and PBCCS-soya yogurt as presented in **Table 1**. The different ingredients among three cream cheese spreads were plant-based yogurts. The Soya cheese was mixed with ingredients and blended until creamy texture as demonstrated in **Picture 3**.

Table 1: Formulation of three plant-based cream cheese spreads

Ingredients	Content (g/100g cream cheese spread)		
	PBCCS-coconut yogurt	PBCCS-almond yogurt	PBCCS-soya yogurt
Soya cheese	75	75	75
Oregano	2	2	2
Ground garlic	2	2	2
Salt	4	4	4
Pepper powder	2	2	2
Coconut yogurt	15	-	-
Almond yogurt	-	15	-
Soya yogurt	-	-	15

PBCCS: plant-based cream cheese spread



Picture 3: Plant-based cream cheese spread (PBCCS)

4. Sensory evaluation of three plant-based cream cheese spreads

A 9-point hedonic scale was widely used to assess the acceptability of food products. The criteria used were: color, texture (creaminess and softness), taste (saltiness, sourness and sweetness), oiliness, flavor, spreadability and overall liking on a scale of 1 to 9, where 9 represented “like extremely” and 1 represented “dislike extremely.” The 3-scale just about right test was used for measuring attribute intensity and acceptability simultaneously (Carvalho et al., 2017). The attributes were designed as continuous line scale with three descriptive principles, low intensity (much too weak) on the left end, just-about-right or acceptance at the center, and high intensity (much too strong) on the right end, with scores ranging from 1 to 3, respectively. If the net score is less than -20, the attribute intensity should be increased. On the contrary, if it is higher than 20, the attribute intensity should be decreased. The net score between -20 and 20 means that the attribute intensity is just about right.

A panel of 50 untrained panelists as target consumers, who liked to consume plant-based cream cheese spread or vegan cheese spread or soybean products, participated in the sensory evaluation. All panelists were staff and students aged ranging between 18 and 50 years, at Panyapiwat Institute of Management. Every panelist was served three different plant-based cream cheese spreads (PBCCS), including PBCCS-coconut yogurt, PBCCS-almond yogurt and PBCCS-soya yogurt with three small pieces of bread and three pieces of plastic butter knife spreaders as shown in **Picture 4**. One cup of water was served to rinse. Samples were blind coded with random three-digit numbers and the order of serving sample was randomized so that each sample occurred equally.



Picture 4: The serving of spreads during the sensory evaluation

5. Consumer acceptance of developed plant-based cream cheese spread

The results of the sensory attributes of three spreads were analyzed and selected. The best formula was chosen to develop. The 100 untrained panelists (target consumer), 18 to 50 years old were conducted at Panyapiwat Institute of Management in partitioned sensory booths and evaluated questionnaire was divided into 2 parts as follows:

Part 1: Questionnaire on the topic of consumer demographics

Part 2: Consumer liking and acceptance of developed plant-based cream cheese spread

6. Statistical Analysis

Three plant-based cream cheese spread data: percentage, mean and standard deviation were analyzed by using IBM SPSS software version 24.0 (IBM, Armonk, NY, USA). Significant differences among treatments were determined at $p < 0.05$ using Duncan's multiple range test.

Results and Discussion

The results revealed that the fifty respondents who attended the sensory evaluation were female (76%) and male (24%), aged ranging from 18 to 50 years. The sensory attributes of three plant-based cream cheese spreads were significantly different ($p < 0.05$) depending on the plant-based yogurt type as presented in **Table 2**. The highest overall liking score (6.54 ± 0.42) was PBCCS-soya yogurt, compared to those two spreads. Each attribute score of PBCCS-soya yogurt resulted in color (6.60 ± 1.00), creaminess (6.63 ± 1.32), softness (6.37 ± 0.24), saltiness (5.37 ± 0.72), sourness (6.24 ± 0.20), sweetness (6.04 ± 1.50), oiliness (6.23 ± 0.80), flavor (6.10 ± 0.60) and spreadability (6.01 ± 1.09). The preference scores of creaminess, sourness, sweetness and flavor of PBCCS-soya yogurt were significantly higher than those of PBCCS-almond yogurt and PBCCS-coconut yogurt ($p < 0.05$). Moreover, the incorporation of coconut yogurt in cream cheese spread led to the lowest liking score in overall liking (5.00 ± 0.22), sourness (4.23 ± 0.30) and flavor (4.07 ± 0.75), which might be due to the

incompatibility of soya cheese and coconut yogurt. The preference score of color and spreadability showed no statistically significant differences at the 0.05 level among three spreads.

Table 2: Sensory attributes of 3 plant-based cream cheese spreads

Attributes		PBCCS-coconut yogurt	PBCCS-almond yogurt	PBCCS-soya yogurt
Color	Light yellow	6.60 ± 1.30 ^{ns}	6.50 ± 0.57 ^{ns}	6.60 ± 1.00 ^{ns}
Texture	Creaminess	5.62 ± 0.01 ^b	5.53 ± 0.74 ^b	6.63 ± 1.32 ^a
	Softness	6.20 ± 1.02 ^a	6.03 ± 1.43 ^b	6.37 ± 0.24 ^a
Taste	Saltiness	5.02 ± 0.52 ^b	5.27 ± 0.22 ^a	5.37 ± 0.72 ^a
	Sourness	4.23 ± 0.30 ^c	5.30 ± 0.10 ^b	6.24 ± 0.20 ^a
	Sweetness	5.58 ± 0.45 ^b	5.30 ± 1.35 ^b	6.04 ± 1.50 ^a
Oiliness		5.08 ± 0.61 ^b	6.10 ± 0.61 ^a	6.23 ± 0.80 ^a
Flavor		4.07 ± 0.75 ^b	4.34 ± 0.83 ^b	6.10 ± 0.60 ^a
Spreadability		6.00 ± 1.00 ^{ns}	6.05 ± 0.70 ^{ns}	6.01 ± 1.09 ^{ns}
Overall liking		5.00 ± 0.22 ^c	5.50 ± 0.49 ^b	6.54 ± 0.42 ^a

PBCCS: plant-based cream cheese spread

Values are means ± standard deviation

Different letters (a–c) in the same row are significantly different at p<0.05

The just about right (JAR) score of three plant-based cream cheese spreads indicated the different consideration as demonstrated in **Table 3**. The results showed that the saltiness of all plant-based cream cheese spreads was too low and considered to be increased, on the contrary, the flavor of three spreads was too high and needed to be decreased. The color and spreadability of the three spreads were just about right. Besides, the sweetness of both PBCCS-coconut yogurt and PBCCS-almond yogurt was not enough and needed to be sweeter. The sourness and oiliness of PBCCS-coconut yogurt were too high and needed to be decreased, whereas the softness and sourness of PBCCS-almond yogurt were too low and needed to be increased.

Interestingly, the plant-based cream cheese spread mixed with soya yogurt presented just about right considerations in color, creaminess, softness, sourness, sweetness, oiliness and spreadability, which should not to be improved (**Table 3**). In addition, the result of just about the right scale was in accordance with the 9-hedonic scale that respondents preferred sensory attributes of the PBCCS-soya yogurt amongst the three spreads. Hence, this spread was selected to develop and study consumer liking and acceptance further.

Table 3: Just-about-right (JAR) consideration of 3 plant-based cream cheese spreads

Sample	Attributes	Intensity (%)			Net score	Consideration
		Too weak	JAR	Too strong		
PBCCS-coconut yogurt	Light yellow	15	75	10	-5	JAR
	Creaminess	15	70	15	0	JAR
	Softness	7	70	23	16	JAR
	Saltiness	36	64	0	-36	Increase
	Sourness	3	63	34	31	Decrease
	Sweetness	44	56	0	-44	Increase
	Oiliness	0	60	40	40	Decrease
	Flavor	23	33	44	21	Decrease
	Spreadability	17	70	13	-4	JAR

Sample	Attributes	Intensity (%)			Net score	Consideration
		Too weak	JAR	Too strong		
PBCCS –almond yogurt	Light yellow	15	55	30	15	JAR
	Creaminess	7	70	23	16	JAR
	Softness	49	51	0	-49	Increase
	Saltiness	43	44	13	-30	Increase
	Sourness	44	53	3	-41	Increase
	Sweetness	37	52	11	-26	Increase
	Oiliness	15	65	20	5	JAR
	Flavor	10	46	44	34	Decrease
	Spreadability	1	70	17	4	JAR
PBCCS –soya yogurt	Light yellow	10	80	10	0	JAR
	Creaminess	11	67	22	11	JAR
	Softness	20	74	6	-14	JAR
	Saltiness	49	51	0	-49	Increase
	Sourness	7	70	23	16	JAR
	Sweetness	26	52	22	-4	JAR
	Oiliness	15	64	21	6	JAR
	Flavor	6	60	34	28	Decrease
	Spreadability	20	72	8	-12	JAR

PBCCS: plant-based cream cheese spread

The plant-based cream cheese spread mixed with soya yogurt was chosen to develop by adding salt and reducing the soya yogurt content. This developed spread was evaluated in terms of the consumer liking and acceptance by 100 untrained panelists who liked plant-based cream cheese spread, vegan cheese spread or soy products (consumer target). The results of the demographics information, as presented in Table 4, revealed that the majority of the respondents were female (65%), aged ranging from 18 to 30 years (70%), and had a bachelor's degree (67%). Most of them were students (55%) and received incomes lower than 10,000 THB (64%).

Table 4: Demographics information of developed plant-based cream cheese spread

Demographics	Percentage (%)
Sex	
Male	35
Female	65
Age	
18-30 years	70
31-40 years	24
41-50 years	6
Education	
Lower than Bachelor	4
Bachelor	67
Master	28
Higher than Master	1

Demographics	Percentage (%)
Career	
Student	55
Teacher	20
Company employee	25
Income	
Lower than 10,000 THB	55
10,001 -20,000 THB	15
20,001 -30,000 THB	18
Higher than 30,001 THB	12

The sensory attributes in terms of consumer liking score in **Table 5** demonstrated that this developed cream cheese spread had the color score at 7.02 ± 1.05 (moderate liking), creaminess score at 6.63 ± 0.32 (slight liking), softness score at 6.57 ± 0.54 (slight liking), saltiness score at 6.37 ± 0.26 (slight liking), sourness score at 6.45 ± 0.26 (slight liking), sweetness score at 6.44 ± 1.31 (slight liking), oiliness score at 6.37 ± 0.89 (slight liking), flavor score at 6.10 ± 0.67 (slight liking), spreadability score at 6.00 ± 0.20 (slight liking) and overall liking score at 6.84 ± 0.91 (slight liking), respectively.

Table 5: Consumer liking of developed plant-based cream cheese spread

Attributes	Developed PBCCS
Color	Light yellow 7.02 ± 1.05
Texture	Creaminess 6.63 ± 0.32
	Softness 6.57 ± 0.54
Taste	Saltiness 6.37 ± 0.26
	Sourness 6.45 ± 0.26
	Sweetness 6.44 ± 1.31
Oiliness	6.37 ± 0.89
Flavor	6.10 ± 0.67
Spreadability	6.00 ± 0.20
Overall liking	6.84 ± 0.91

PBCCS: plant-based cream cheese spread
Values are means \pm standard deviation

The respondents (target consumers) mostly accepted (81%) the developed plant-based cream cheese spread as shown in **Table 6**. The respondents provided the main reasons for acceptance of this spread: taste (30%), plant-based product (21%), new product (20%), texture of spread (15%), and zero meat or animal ingredients (14%). However, approximately 19% of respondents did not accept this product due to the following reasons: unpleasant odor (50%), beany flavor (30%) and unfamiliarity (22%) with this product. The research of Li et al. (2013) described that the beany flavor from soybeans occurred as a result of lipoxygenase activity, which did not occur in undamaged raw soybeans; however, in the presence of water and oxygen, an enzymatic process took place and emphasized off-flavors. These attributes were often considered to be “off characteristics” which diminished the overall quality and acceptance of the soya cheese spread. For the purchase decision of the spread at 79 THB per 100 g, the panelists mostly decided to purchase this product 79%, though minor panelists decided not to buy 21%. They mentioned that the spread needed to further developed and improved.

Table 6: Consumer acceptance of developed plant-based cream cheese spread

Consumer Acceptance	Percentage (%)
Product acceptance	
Acceptance	81
Denial	19
Why did you accept this product? (Acceptant respondents 78%)	
New product	20
Plant-based product	21
Zero meat/animal ingredients	14
Taste	30
Texture	10
Nutritional benefits	5
Why did you deny this product? (Deniable respondents 22%)	
Not familiar	22
Unpleasant odor	50
Beany flavor	30
Taste	15
Purchasing decision (cream cheese 79 THB/100 g)	
Decide to buy	76
Decide not to buy	24

Conclusion

Three plant-based cream cheese spreads were compared for their sensory attributes, including consumer liking and just-about-right consideration. The results revealed that the highest overall liking score was observed in PBCCS-soya yogurt, followed by PBCCS-almond yogurt and PBCCS-coconut yogurt, respectively. The PBCCS-soya yogurt presented just about right score in various attributes, namely color, creaminess, softness, sourness, sweetness oiliness and spreadability. Therefore, the PBCCS-soya yogurt was selected for develop by adjusting the salt and soy yogurt contents. After that, this developed spread was evaluated the consumer liking and acceptance. The respondents (target consumers) liked this spread slightly (6.84 ± 0.91) and eighty-one percent of respondents accepted this spread. They decided to purchase this product at 76% of the price of 79 THB per 100 g. However, the additional study on the development of this product is needed.

Acknowledgments

The authors wish to acknowledge the laboratory assistants of Mr.Tanawit Noensanit, Ms. Tanatcha Taepphan, Mr. Kritsana Srimoon, Mr.Kritsanapong Kaewduangdee, Mr.Teerawat Chongkul and Ms.Naamtip Nitiyawongsa. We are also grateful to the Department of Food Business Management, Panyapiwat Institute of Management, Thailand for financial support.

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