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Development of Sweetened Condensed Creamer made of Thai Pathumthani Rice (Hom-Pathum) Milk

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Abstract

Thai Pathumthani Rice (Hom-Pathum) is a Geographic Indication (GI) product cultivated in Thailand. Plant-based milk production has gained popularity due to its lower greenhouse gas emissions, water use, and land utilization than dairy milk. Sweetened condensed cream is a concentrated dairy product made by eliminating a lot of water from cream and adding sugar for stability, texture, and shelf life. Its creamy texture, high fat content, and sweetness make it popular in confectionery, bakery, and desserts. This study was aimed to utilize the whole Hom-Pathum rice for Hom-Pathum rice milk (HPRM) production and formulate a sweetened condensed creamer (SCC) product. The acquired SCC was assessed for its physical, physico-chemical, biological activity, chemical composition, and microbiological properties. The results showed that the ratio of rice to water 1:10 (%w/v) was suitable for HPRM production and processes to SCC product. The color of obtained SCC made of HPRM (HP-SCC) was significantly different in L^* value (76.31±2.43) when compared to commercial sweetened condensed cream (CSCC), 72.83±3.01, (p<0.05). No difference was observed in pH, water activity (A_w) and total acidity value of final product compared with CSCC (p>0.05). The viscosity of HP-SCC showed the consistency (7,642.63±29.78cP) with commercial product. The HP-SCC enhanced antioxidant activity and eliminated hazards from pathogenic bacteria, resulting in a safe product. These findings may serve as preliminary results for the creation of HPRM and HP-SCC products that fulfill consumer quality standards.

Keywords: Hom-Pathum Rice, Plant-Based Milk, Sweetened Condensed Cream, Alternative Fat Ingredient, Healthy Creamer

1. Introduction

The growing global demand for sustainable and health-oriented dietary options has resulted in a notable increase in the use of plant-based milk (1). Plant-based milk, sourced from botanicals including soy, almonds, oats, coconut, and rice, provides an alternative to traditional dairy milk for those with lactose intolerance, milk allergies, ethical issues, or environmental reasons (2). In contrast to dairy milk, which originates from animal sources, plant-based milk is generally created by extracting components from plants and subsequently fortified with vital elements like calcium, vitamin D, and vitamin B12 to improve its nutritional value (3-4).

Pathum Thani rice, which originates from the Pathum Thani region of Thailand, represents a significant advancement in the cultivation of rice in Thailand. It combines aromatic qualities with exceptional agronomic traits. Farmers were provided with a viable alternative that boasts better yield potential and adaptability when Pathum Thani rice was produced. This was done in order to overcome the limitations that were associated with the typical Thai jasmine rice, also known as Hom Mali (5). The scent and flavor of Pathum Thani rice are quite similar to those of the highly regarded Thai jasmine rice. This is because Pathum Thani rice maintains the aromatic qualities that Thai jasmine rice is so well-known for. There are not many in-depth nutritional evaluations of Pathum Thani rice; however, the fact that it is comparable to jasmine rice suggests that it most likely includes similar nutritional features (6). These characteristics include essential components such as carbohydrates, proteins, and vitamins.

Sweetened Condensed Creamer (SCC) has become a cost-effective substitute for conventional Sweetened Condensed Milk (SCM), addressing various consumer preferences and financial factors (7). SCC is often composed of non-fat dairy powders, vegetable oils (8), and sugar, and is frequently employed as a coffee creamer (9), cake topping (10), or component in diverse beverages. The evolution of SCC demonstrates the industry's endeavors to offer economical substitutes for conventional sweetened condensed milk (11). The formulation of SCC requires the equilibrium of protein content, the characteristics of dairy powders, and the judicious application of stabilizers to guarantee product quality and stability (12). Current research and innovation in this field persist in tackling the issues related to protein reduction, striving to satisfy consumer needs while preserving the essential sensory and functional attributes of the product.

The global market for plant-based creamers, particularly rice milk creamers, has grown due to changing consumer tastes and technology (13). Veganism and lactose intolerance have increased demand for dairy alternatives such rice milk-based creamers. Rice milk creamers are hypoallergenic and suitable for many diets, making them appealing to plant-based consumers (14). Plant-based creamers are better and more appealing thanks to production innovations (2). Enzymatic and cold-pressing processes improve flavor and nutrient retention, while microencapsulation improves flavor stability and texture. Rice milk-based creamers are now more competitive with regular dairy products due to these sensory improvements (1). The SCC derived from rice milk offers a hypoallergenic, easily digested, and adaptable substitute for conventional dairy creamers, accommodating various dietary preferences and requirements (7).

Rice milk, particularly from region-specific cultivars like Thai Pathumthani Rice (Hom-Pathum), offers significant nutritional and environmental benefits, yet its use in value-added dairy substitutes is rare. Thai rice milk's functional, sensory, and nutritional qualities are unclear because most research and commercial development has focused on soy, almond, and oat milk. Taste, texture, and shelf stability all lacking in rice milk-based sweetened condensed creamer. This study uses Hom-Pathum rice milk in a sweetened condensed creamer to diversify plant-based dairy alternatives and value local rice varieties, and there was no reported for milk production and SCC applications. Consequently, the objective of this study is to create SCC from Hom Pathum rice milk and to assess the product's inherent quality for contemporary consumers in the 21st century.

2. Materials and Experiment

2.1 Thai Pathumthani (Hom Pathum) rice preparation.

Thai Pathumthani (Hom-Pathum) rice was acquired at the Tesco shop in Pathum Thani province, Thailand. The rice was pulverized and subsequently processed using a screening machine (Retsch, AS200 Digit) with a 35 mesh (500 µM) and stored under vacuum conditions at -18°C. This sample served as the initial material for the manufacturing of Thai Pathumthanee rice milk.

2.2 Sweetened condensed creamer (SCC) made of Thai Pathumthani (Hom-Pathum) rice milk production

Thai Pathumthani rice milk was made following the methodology of Faccin et al. (15) with certain modifications. The rice-to-water ratio was adjusted to 1:5, 1:10, and 1:15 (%w/v). The mixtures were subsequently blended with a colloid mill machine at a speed of 3,000 rpm for 15 minutes (ASAKO, YJTM85D-2P, China). The resultant suspension was filtered through cheesecloth three times. The filtrate was subsequently pasteurized at 72°C for 15 seconds and designated as "Hom-Pathum Rice Milk: HPRM." Following thermal processing, the HPRM was subjected to cooling. The acquired HPRM was contained in a 150 ml polypropylene (PP) plastic container utilizing aseptic procedures and sealed with Parafilm®M Laboratory Film.

The SCC composed of HPRM (known as HP-SCC) was synthesized by including sugar (65% w/v), maltodextrin (17% w/v), vegetable oil (15% w/v), vanilla flavor (0.5% w/v), colorant (food grade, 0.5% w/v), and carboxymethylcellulose (CMC: 2% w/v). All ingredients were blended until a homogenous solution was achieved using a homogenizer. The acquired viscous sample was placed into the bottle and sterilized using a sterilization machine. The material was chilled and maintained at room temperature for subsequent examination.

The commercial sweetened condensed creamer (CSCC) was purchased from the local supermarket in Pathum Thani province, Thailand and used as a commercial control sample for comparison.

2.3 Proximate analysis

The methodologies of the Association of Official Analytical Chemists quantified moisture, total ash, and total lipid HPRM (16). AOAC-compliant crude fiber analyzers (Foss Tecator 10.1, Sithiphorn Associates Co., Ltd.) performed acid and alkaline digestion of crude fiber. The Kjeldahl method was employed to determine total nitrogen using a protein conversion factor of 5.95. The subtraction produced the total carbohydrate amount.

2.4 Physico-chemical properties

2.4.1 Color measurement

The Color Quest XE (Hunter Lab, Virginia) was utilized to evaluate the color of HPRM and CSCC (17). The sample's color was denoted as L^*, a^*, b^*, and ΔE. The procedure for determining the whiteness and ΔE of HPRM and CSCC is as follows:

$$\Delta E = \sqrt{(L^* - L^{*\prime})^2 + (a^* - a^{*\prime})^2 + (b^* - b^{*\prime})^2} \qquad (2.1)$$

$$Whiteness = 100 - \sqrt{(100 - L^*)^2 + (a^*)^2 + (b^*)^2} \qquad (2.2)$$

Where: $L*$ represents lightness, $a*$ represents greenness (−) or redness (+) and b^* represents blueness (−) or yellowness (+).
The subscripts 1 and 2 represent the two different color measurements being compared.

2.4.2 pH measurement

The pH of HPRM and CSCC was assessed utilizing a pH meter, in accordance with the methodology described by Issara & Rawdkuen (18). A 30 ml sample volume was placed into a 50 ml beaker, and the pH of the sample was subsequently tested in three replicates.

2.4.3 Water activity (A_w) test

The water activity (aw) of HPRM and CSCC was measured using a water activity instrument (Novasina AWC500, Switzerland), with the A_w value documented at 25±1°C.

2.4.4 Total acidity determination

Total acidity was assessed using the method of Issara & Rawdkuen (17) with some modification. Two grams of sample were measured and placed in a 250 ml Erlenmeyer flask with 90 ml distilled water. Next, 2-3 drops of phenolphthalein were added and titrated with NaOH until the endpoint was pink.

2.4.5 Viscosity determination

A modified approach established by Faccin et al. (15) was employed to ascertain the viscosity of HPRM and CSCC. The UL Adapter spindle (UL-0) No. 00 probe and a Brookfield viscometer (Brookfield Engineering Labs Inc., Middleboro, Massachusetts 02346, USA) were employed in this experiment.

2.4.6 Stability test of HPRM

The stability of organic HPRM was evaluated by putting it into a 10 ml cylinder. The substance was thereafter kept at 4°C for stability evaluation. The sample was observed for precipitate formation on days 0, 3, 5, and 7, and the findings were recorded Issara & Rawdkuen (18).

2.5 Biological activity determinations

2.5.1 Determination of total polyphenol content

The ISO technique was used to quantify total polyphenol content using gallic acid with following the method of Issara & Rawdkuen (17). In brief, about 2.5 ml of 10% v/v Folin-Ciocalteu reagent was added to tubes with 0.5 ml of sample. Next, 2.0 ml of 7.5% w/v sodium carbonate was added. After one hour at room temperature, UV-visible spectroscopy detected absorbance at 765 nm. Polyphenol content was measured in gallic acid equivalents (GAE) per 100 grams of extract.

2.5.2 Determination of radical scavenging activity (DPPH)

The DPPH assay was conducted following Issara & Rawdkuen (17). Fifty microliters of the sample were combined with 1950 microliters of a 60 µM DPPH solution. The combinations were subsequently placed in a dark environment for 30 minutes, after which the absorbance was measured at 517 nm. The radical scavenging activity was quantified as µmol Trolox per 100g on a dry basis.

2.6 Microbiological analyses

Altered method from sources (19-20) to determine Total Plate Count, *Escherichia coli* / Coliform, *Staphylococcus aureus*, Yeast & Mold, and *Bacillus cereus*. The analyses were performed using 3M Petrifilm^{TM} techniques under AOAC and BAM (17). A ziplock bag with 90 milliliters of sterile 0.1% (w/v) buffered peptone water contained 10 grams of HPRM samples. The stomacher machine (model 400 Circulator) was used to mix for 3 minutes, and each bacterium was diluted in 0.1% BPW in duplicates on 3M Petrifilm^{TM}, except for *B. cereus*, which was transferred to nutritional broth agar plates. The CFU/g bacterium count was tested.

2.7 Statistical analysis

All measurements were duplicated. ANOVA and Duncan's multiple range test at 95% confidence were used in SPSS 20.0 for Windows (SPSS Inc, Chicago, IL) to analyze the findings with some determination and the t-test was used to compare the optimal product with the commercial product.

3. Results and Discussion

3.1 Proximate composition of HP-SCC made of HPRM

In Table 1, the constituents of Hom-Pathum rice, HPRM, and CSCC are specified in their respective forms. With the exception of the moisture level, the proximate composition of HPRM was significantly higher than that of HP-SCC and CSCC products (p<0.05). Based on the findings, it was determined that the HPRM was able to preserve all of the components of the rice during the operation of the colloid mill process. In comparison to the findings of earlier research, the constituents of Thai organic rice were found to have varying levels of concentration. The research conducted by Kukusamude et al. (19) demonstrated that a number of Thai rice varieties include a range of carbs (43.5% to 54.3%), protein (14.1-18.2%), fat (1.6-20.9%), ash (12.8-15.3%), and fiber (8.7% to 10.5%). In their study, Siripattanakulkajorn et al. (20) came to the conclusion that changes in rice composition might be linked to a variety of sources and species of rice. In addition, because of the ratio of rice to water, the amount of all components decreased, with the exception of the moisture content. It is the diluting effect and the extractability of the compounds that are present in rice that are responsible for this phenomenon.

Table 1 Proximate composition of Hom-Pathum rice, HPRM and HP-SCC and CSCC.

Samples	Compositions (g/100g)*					
	Moisture	Ash	Protein	Fat	Fiber	Carbohydrate
Hom-Pathum Rice	66.38±0.02	77.27±0.82	111.15±0.52	11.48±0.05	77.44±0.15	666.28±3.14
HPRM 1:5	889.19±2.46c	22.68±0.63a	33.76±0.13a	00.79±0.035a	22.12±0.03a	11.46±0.10b
HPRM 1:10	991.38±5.09b	11.17±0.25b	22.39±0.25b	00.61±0.27b	11.97±0.09b	22.48±0.36a
HPRM 1:15	994.12±4.83a	00.94±0.31c	22.07±0.16c	00.46±0.66c	11.43±0.14c	00.98±0.07c
HP-SCC	774.69±4.31	11.09±0.04	11.89±0.76	110.48±0.97	11.52±0.26	110.33±0.54
CSCC	770.94±2.67	00.98±0.08	11.71±0.42	119.04±0.95	00.88±0.19	66.45±0.18

*Mean±Standard Deviation of triplicate measurements
Means with differing letters in the same column are significantly different at (p<0.05).

In comparison to CSCC compositions, HP-SCC exhibited substantial differences in moisture, protein, fat, and carbohydrate content ($p<0.05$). The extraction medium and conditions significantly impact protein extraction and affect protein recovery (24). When comparing HPRM to other beverages, such as plain milk, and soy extract, it was observed that the carbohydrate content was higher than in those samples. A comparable finding was observed in a prior investigation, indicating that the HPRM had a recovery composition, with carbohydrates constituting approximately 0.98-10.33%. The carbohydrate content of the HP-SCC may be attributed to the sugar concentration incorporated in its manufacture formula. Simultaneously, the CSCC was composed primarily of palm oil.

The optimal ratio of rice to water for producing HPRM, based on chemical composition and nutritional value, is 1:10 (%w/v). This sample was gathered for the production of HP-SCC and its inherent characterization.

3.2 Physico-chemical, biological properties and stability measurement

The features of color that are associated with HP-SCC and CSCC are outlined in Figure 1 and Table 2. One of the most important aspects of food goods that directly affects the level of approval they receive from customers is their color aspect. The maximum values of whiteness and lightness (L^*) that were reported in HP-SCC were 79.71±3.45% and 76.31±2.43, respectively. According to the findings, there was a significant decrease in the values of L^*, redness (a^*), and yellowness (b^*) of the HP-SCC sample as the water ratio increased ($p<0.05$). When compared to CSCC, the whiteness of HP-SCC was significantly higher ($p<0.05$). These characteristics have the potential to serve as very important criteria and factors to take into consideration for the continuous development of rice milk.

Table 2 Color characteristics of HP-SCC and commercial CSCC.

Samples	Color Parameters*				
	L^*	a^*	b^*	ΔE	Whiteness (%)
HP-SCC	76.31±2.43a	3.67±0.81a	21.76±1.44a	8.07±0.48	79.71±3.45a
CSCC	72.83±3.01b	2.14±0.42b	19.62±21.01b	-	74.49±4.02b

*Mean±Standard Deviation of triplicate measurements
Means with differing letters in the same column are significantly different at ($p<0.05$).

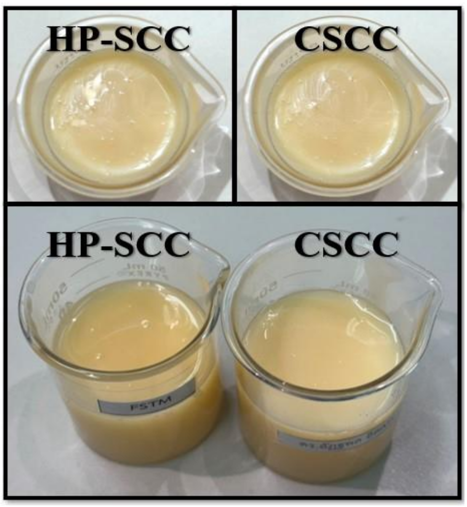

Figure 1 The HP-SCC compared with CSCC product.

Table 3 Physico-chemical, biological properties and stability of HP-SCC and CSCC.

Parameters	Samples*	
	HP-SCC	CSCC
pH	6.89±0.01a	6.99±0.01a
Water activity (A_w)	0.76±0.34a	0.78±0.57a
Viscosity (cP)	7,642.63±29.78b	9,278±49.5a
Total acidity (%)	0.49±0.07a	0.37±0.08b
Total phenolic content (mg gallic acid/g sample)	784.56±25.02a	220.49±31.88b
DPPH assay (μmol Trolox/g sample)	445.67±18.70a	175.39±10.89b
Stability (at day 7)	++	+++

*Mean±Standard Deviation of triplicate measurements
Means with differing letters in the same column are significantly different at (p<0.05).
+Indicate the stability of the finished product, ensuring no phase separation occurs (a high numerical value +++ signifies elevated stability) and – means sample was precipitation.

Physico-chemical, biological properties and stability of developed HP-SCC and CSCC are also presented in Table 3. pH and total acidity were determined since they were used to identify the shelf-life of the products. For chemical properties, pH of HP-SCC and CSCC ranged from 6.89±0.01-6.99±0.01. Total acidity of HP-SCC was 0.49±0.07%. The maximum viscosity was found in CSCC (9,278±49.5cP) when compared to HP-CSCC (7,642.63±29.78cP). Hence, these properties could be used to further new plant-based milk development.

The stability of HP-SCC using the coagulation process (the image was not shown) was observed and illustrated in Table 3. The greatest stability of product was observed in the CSCC compared to HP-SCC formulated with rice milk at a ratio of 1:10 (%w/v). The separation phase intensified with prolonged storage duration, particularly on day 7. Despite undergoing the colloid mill process, the HPRM still retained macro particles suspended in the final product. Consequently, the phase separation between the soluble and insoluble fractions was distinctly visible in HPRM from the initial day of analysis, particularly in treatments with a higher concentration of extractant. Furthermore, during thermal processing, the chemical structure of the composition may be compromised and destabilized inside the colloidal system, leading to instability in the final product over time during storage.

3.3 Microbiological determination

The microbial count in HP-SCC was calculated and recorded during the course of a seven-day storage period, and the results are provided in Table 4. Based on the findings, it was determined that the HP-SCC product did not include any hazardous bacteria, specifically *E. coli* / Coliform, *Staphylococcus aureus*, and *Bacillus cereus*, and hence demonstrated compliance with the standards governing food safety. After storage at room temperature for seven days, the total microbial count of HP-SCC product ranged from 0.9×10^2 to 2.4×10^2 CFU/g for the course of the experiment. Ultimately, the amount of yeast and mold that was present in HP-SCC product was detected to be between 9 colony-forming units per gram after it had been stored for the end of the experiment day. In a study that Puerari et al. (21) carried out on the physicochemical and microbiological features of beverages that were manufactured with rice as the raw material, the researchers found that the product contained lactic bacteria (*Bacillus subtilis* and *Bacillus cereus*) as well as yeast. The study emphasized that cereals and items related to them often have a high carbohydrate content, which serves as a favorable environment for the growth of lactic bacteria, as well as the metabolites that these bacteria produce and other metabolic processes (22). In addition, the sample had a pH level that ranged from 6.89±0.01 to 6.99±0.01, which was extremely conducive to the proliferation of microorganisms (22-23).

Table 4 Microbiological examination of HP-SCC for 7 days storage time (at room temperature).

Sample	Number of microbials (CFU/g)*					
	days	Total plate count	*E. coli* / Coliform	*Staphylococcus aureus*	*Bacillus cereus*	Yeast & Mold
HP-SCC	0	0.9×10^2	ND**	ND	ND	ND
	3	1.1×10^2	ND	ND	ND	ND
	5	2.1×10^2	ND	ND	ND	ND
	7	2.4×10^2	ND	ND	ND	9

*The values are expressed as Mean (n=2) for rapid method refer as 3M Petrifilm™ **ND = Not detect

4. Conclusions

This study investigates the application of Thai Pathumthani Rice (Hom-Pathum) milk in the formulation of a sweetened condensed creamer, providing an innovative, plant-based substitute for conventional dairy creamers. The acquired HPRM exhibited satisfactory physical and chemical characteristics. HPRM may serve as a novel plant-based beverage and be developed for health-conscious consumers. The rice-to-water ratio of 1:10 (%w/v) is appropriate as an initial parameter for the creation of alternative SCC products. However, HPRM requires additional experimentation to enhance its quality qualities, particularly taste and flavor, utilizing these fundamental results. Moreover, the study promotes agricultural sustainability and enhances the value of Thai rice products by employing a locally cultivated rice variety. The results possess potential implications in the rising market for lactose-free, vegan, and allergen-friendly foods, enhancing food innovation and broadening consumer choices in both domestic and international markets.

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Declaration of Conflicting Interests

The authors state that they have no knowledge of competing financial interests or personal relationships that could have influenced this paper.

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