Optimization of process conditions for the development of rice milk by using response surface methodology

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Abstract. Rice milk is a dairy product alternative for who are allergenic milk protein, lactose and concern about cholesterol. Unlike cow’s milk, rice milk contains little protein but has a higher carbohydrate content. The purpose of this research was to study the optimal condition to develop rice milk nutritionally equivalent to cow milk with consumer acceptability. In this study, we used rice protein concentrate, rice flour, rice bran oil, sugar and calcium lactate as ingredients. Firstly, the selection of enzymes for rice protein hydrolysis was carried out and neutrase had high degree of hydrolysis with the highest consumer acceptability (p<0.05). Response surface methodology (RSM) base on central composite design was then employed to investigate the optimum condition with three independent variables: enzyme: protein ratios, speeds and times of homogenization. Our results reveal that the experimental variables significantly affected the color and sensory attributes. The optimum condition for rice milk production was found to be 16000 rpm, 20 minutes of homogenization and 1:40 (w/w). The milk produced from this condition had protein 3.14 %, fat 3.28%, fiber 0.45%, ash 0.44% moisture 86.85% and carbohydrate 5.84%, which was similar to the nutritional value of cow’s milk. The developed product showed good nutritional and sensory characteristics and this could be used for the development of commercial rice milk beverage after conducting appropriate scale up and pilot plant study.

1. Introduction
Cow’s milk is one of the most consumed food relished by human population since ancient time due to its nutritional value and its convenience in satiating appetite. Nowadays, its consumption has raise concerned about the health awareness. Clinical researches have demonstrated that some components of cow’s milk are allergy, hypercholesterolemia, lactose intolerance or coronary heart accomplice with health problems including milk protein diseases [1,2,3]. For these reasons, consumers have become more interested in non-dairy alternatives over cow’s milk. In recent years, plant-based milks products such as soy milk, almond milk, coconut milk, rice milk and cashew milk have been lanched on markets by various food industries worldwide and rice milk is one of the most popular dairy free alternatives in Asian countries such as China, Japan, Vietnam and Thailand [4]. This beverage can be prepared by using milled broken rice or rice flour with water and communition to a size range of 5-20 μm through homogenization [5]. Heating is applied during the milk process, mostly to ensure food safety and extend the shelf life of the product [6]. Rice based milk generally present inferior nutritional substitutes of
bovine milk, in which it is very rich in carbohydrate (9.4-14.2 g 100 ml\(^{-1}\)) but contains small amounts of protein (0.1-0.8 g 100 ml\(^{-1}\)) and fat (0.8-0.2 g 100 ml\(^{-1}\)) also lacks of calcium and vitamins [7]. Consumption of rice milk as an alternative’s without suitable care can result in malnutrition, especially in the case of infants and toddlers [8].

Rice base milk alternative contains blend of rice protein concentrate, rice bran oil, sugar and calcium lactate can increase its nutritional value and could be equivalent to cow’s milk nutrition. Rice protein is hypoallergenic and suitable for people allergic to cow or soy milks [9]. The use of rice protein ingredient in food and sports nutrition as an alternative to the more commonly used casein, whey and soy protein, is increasing but limit its applications to products that do not require high solubility of the protein ingredient such as meat analogues, baked goods, protein bars because rice protein is low solubility in water [10]. The functionality of rice protein may be improved by using enzyme hydrolysis. According to the study of Humiski et al. [11] protease enzymes such as an alcalase, flavourzyme, trypsin can be used to increase the solubility of pea proteins. The effect of enzymatic hydrolysis is dependent on various factors such as type of enzyme [12,13] treatment conditions (enzyme-substrate ratio, reaction temperature, time of enzyme action, characteristics of substrate [14]. Moreover, it has been found that using combination between homogenization and high temperature during milk production could increase protein solubility [15,16]. Response surface methodology (RSM) is a widely used mathematical and statistical method for modeling and optimizing a process, which requires minimum experimentation [17]. The purpose of this research was to evaluate the effect of enzymatic hydrolysis of rice protein concentrates on the solubility of the resulting hydrolysates and study the optimal condition to develop rice milk nutritionally equivalent to cow’s milk with consumer acceptability.

2. Materials and methods

2.1. Materials

Rice flour was purchased from a local supplier (Thaiflour industry company limited, Thailand). Rice protein concentrate was obtained by Fenchem co. ltd and rice bran oil was obtained by Thai edible oil co., ltd (Thailand). Calcium lactate was purchased from Bkkchemi Co., Ltd. Rennet enzyme 2000 U/g was obtained by Tinnakorn Chemical and Supply Co., Ltd. Flavourzyme1000LAPU/g, Alcalase 2.4 AU-A/g and Neutrase 0.8AU-Nu/g were supplied by Brenntag Ingredients (Thailand) Co., Ltd. All other chemicals and reagents were of analytical grade.

2.2. Enzymatic screening for improved protein solubility

2.2.1. Hydrolysis of rice protein concentrate. Enzymatic hydrolysis of rice protein concentrate was studied by using the modified method of Barać et al. [18]. Four protease enzymes including rennet, flavourzyme, alcalase and neutrase were explored as the part of enzymatic screening. The factors affecting the degree of hydrolysis such as pH (5, 6, 7) and reaction time (0, 15, 30, 60, 120 minutes) were also investigated. Protein concentrate solution was prepared at 4% (w/w) then the pH was adjusted to 5, 6, 7 with 1 M NaOH or 1M HCl. The enzyme to substrate (E/S) ratio was 1:200 was later added to the solution. Incubated at 50 °C then inactivate the enzyme immediately at 80 °C for 10 min. The hydrolyzed proteins were immediately used for the determination of the degree of hydrolysis.

2.2.2. Degree of hydrolysis. Degree of hydrolysis (DH) was determined according to the method of Barać et al. [18]. The protein hydrolysate solution was centrifuged at 12000×g for 15 minutes. Then 10 ml of supernatant was taken to mix with 10 ml of 20% w/v trichloroacetic acid (TCA) and centrifuged at 12,000 g for 15 minutes. The soluble protein content of the supernatant was determined by the Lowry method [19] using bovine serum albumin as the standard. Total nitrogen was determined from 10 ml of suspension prepared in the same way as for enzymatic hydrolysis, but without the enzyme [20].

\[
\text{DH(%) = \left(\frac{\text{soluble protein content in 20 %w/v of TCA (mg) }}{\text{total protein content (mg)}}\right) \times 100}
\]
2.3. Manufacture of rice milk

First, preparing rice protein hydrolysates using 4% (w/v) rice protein with 0.4-0.04 g of enzymes at the reaction temperature of 50°C then inactivating at 80°C for 10 minutes. Then the rice protein hydrolysate was mixed with the following ingredients: 6.1 g rice four gelatinized (12%w/v of rice flour gelatinized at 70 °C 5 minutes) according to Coda et al. [21], 4 g rice bran oil, 4.5 g sugar and 1g calcium lactate. Then homogenized at speed varying from 8000 rpm to 16000 rpm for 5 to 20 minutes. Each rice milk formulation was suggested by the mixture design based on a central composite design as shown in Table 1.

2.4. Experimental design

The optimum condition for development of rice milk formulation was determined by Central Composite Design with response surface methodology (RSM) using 3-level-3-factors in the Design-Expert (7.00) software. In the experimental design, it showed twenty formulations with six replications of the central point. Independent variable parameters were speed of homogenize (X₁), time of homogenize (X₂), enzyme content (X₃) and varied from -1 to +1 (Table 1). Dependent variable parameters were apparent viscosity, color expressed as L*, a*, b* values and sensory analysis. The regression model was used to generate contour maps for optimization and explanation of parameters effecting rice milk properties.

**Table 1.** Independent variables and their levels used for Central Composite Rotatable Design.

| Independent variables         | Symbol | Coded variable levels |
|------------------------------|--------|-----------------------|
| Speed of homogenize (rpm)    | X₁     | 8000  12000  16000   |
| Time of homogenize (min)     | X₂     | 5.00  12.50  20.00   |
| Content of enzyme (g)        | X₃     | 0.04  0.22  0.40     |

The regression model equation for viscosity (Y₁), color L* (Y₂), color a* (Y₃), color b* (Y₄), bitterness (Y₅), smoothness (Y₆), roughness (Y₇), aftertaste(Y₈) could be speculated as follows:

Yₙ = β₀ + β₁X₁ + β₂X₂ + β₃X₃ + β₄X₄ + β₅X₅ + β₆X₆ + β₇X₇ + β₈X₈ + β₉X₉ + β₁₀X₁² + β₁₁X₂² + β₁₂X₃²

Where a dependent variable Y expressed response viscosity, color L*, color a*, color b*, bitterness, smoothness, roughness, aftertaste. The β₀, β₁ and β₂ expressed constant coefficients of the intercept, linear, quadratic and interaction terms, respectively. After study the optimum condition validation was carried out to check the validity of the predicted value suggested from RSM.

2.5. Apparent viscosity measurement

The apparent viscosity of rice milk was measured by viscometer (Brookfield DV-III Ultra programmable viscometer, MA, USA) with small sample adapter (spindle sc4-31) at sample size of 9 ml. Five different shear rates was used (6.60 13.2 19.8 26.4 and 33.0 S⁻¹). The results are presented in pascal-seconds (Pa.s) [22].

\[ \tau = K\gamma^n \]

τ is shear stress (Pa), k is consistency coefficient in (Pa/s), γ is shear rate (s⁻¹) and n is flow-behaviour index.

2.6. Color measurement

Color was measured using a hunter colorimeter (Color Quest II, Reston, USA). Samples were contained in optical glass cells 3.8 cm high and 6 cm diameter. Results were given in CIELAB system for
illuminant D 65 and a 10° angle of vision. Registered parameters were: L* (brightness), a* (red component), b* (yellow component) [23].

2.7. Sensory analysis
Sensory analysis of the hydrolytic rice protein concentrate solution as obtained from 2.2.1 was evaluated using 9 points hedonic scale (1 = “liked extremely”, 5 = “neither liked nor disliked” and 9 = “disliked extremely”) with 30 untrained panelists for bitterness, roughness and overall preference according to the method of Pokora M et al. [24]. For analysis each formulas of rice milk products from experiment design using intensity analysis modified method of Christine Wilson et al [25] by using ten-point scale (rating from 1 to 10) to rate each descriptor's intensity with 30 untrained panelists for bitterness, roughness, smoothness and aftertaste.

2.8. Proximate analysis
Calcium content and proximate analysis procedures for moisture, protein (N*6.25), fat, ash, fiber, carbohydrate of rice milk product was performed according to AOAC 2000 [26].

2.9. Statistical analysis
Analysis of variance (ANOVA) was carried out to analyze the differences between groups. Data was indicated as mean ± SD and statistically significant differences were determined at p ≤0.05. Minitab release 16 (Minitab Inc., State college, USA) was used to carry out all statistical analyses.

3. Result and discussion
3.1. Enzymatic screening for improved rice protein solubility

3.1.1. Effect of pH on enzymatic hydrolysis. In this experiment, the enzyme to protein ratio was fixed at 1:200 g and the reaction time was set at 60 minutes. It was found that pH significantly influenced on enzymatic hydrolysis (p ≤0.05) as shown in Table 2. Among the enzymes studied, alcalase showed the highest degree of rice protein hydrolysis, followed by neutrase, flavourzyme and rennet, respectively and pH 7 was the optimum condition. The obtained results were compatible with those reported by Zhang et al. [27] who studied the solubility of soy protein and rice protein at various pH with enzyme acalase. They found that rice proteins at pH more than 6 had higher degree of hydrolysis and Amiza et al. [28] found that neutrase to hydrolysis mixture of angle wing clam flesh at pH 7 and long reaction time caused higher % Degree of hydrolysis.

Table 2. Degree of rice protein hydrolysis from different enzymes at various pH.

| pH  | Alcalase  | Neutrase  | Flavourzyme | Rennet   |
|-----|-----------|-----------|-------------|----------|
| pH 5| 0.9±0.01  | 1.01±0.003| 1.19±0.04   | 0.38±0.02|
| pH 6| 5.68±0.37 | 3.62±0.07 | 0.88±0.03   | 0.30±0.03|
| pH 7| 8.79±0.05 | 5.74±0.14 | 1.02±0.02   | 0.29±0.01|

Values that are not followed by the same letter within the same column are significantly different (P ≤0.05).

3.1.2. Effect of reaction time on enzymatic hydrolysis. In this experiment, the ratio of enzyme to protein was fixed at 1:200 and at pH 6. Table 3 showed that when the reaction time increased, the % degree of hydrolysis increased significantly (p<0.05). The enzyme reaction time of 120 minutes had the highest % Degree of hydrolysis. Haslaniza et al. [29] reported that a longer reaction time would allow enzyme to act more extensively on the protein, thus resulting in more % degree of hydrolysis.
Table 3. Degree of rice protein hydrolysis from different enzymes at various reaction time.

| Time | %DH | Alcalase | Neutrease | Flavourzyme | Rennet |
|------|-----|----------|-----------|-------------|--------|
| 0    |     | 2.84±0.12 | 0.94±0.02 | 0.58±0.02  | 0.24±0.00 |
| 15   |     | 3.49±0.02 | 3.07±0.01 | 0.67±0.02  | 0.29±0.01 |
| 30   |     | 4.57±0.02 | 3.63±0.04 | 0.79±0.02  | 0.33±0.01 |
| 60   |     | 5.68±0.37 | 3.64±0.07 | 0.88±0.03  | 0.30±0.03 |
| 120  |     | 6.33±0.18 | 5.84±0.12 | 0.92±0.00  | 0.37±0.01 |

Values that are not followed by the same letter within the same column are significantly different (P ≤ 0.05).

3.1.3. Sensory analysis for enzyme selection. Since enzyme alcalase and netrease had a higher DH than rennet and flavourzyme from the previous experiments therefore we selected alcalase and netrease enzymes for sensory analysis. Neutrase enzymes had higher score in aroma, sweetness, bitterness, roughness and overall acceptance than alcalasse. Therefore, neutrase enzyme was selected for the study of the optimum conditions for rice milk production.

3.2. Conditions for optimum responses
The experimental results using RSM with CCD were presented in Table 4 and 5. Three independent variables used were speed of homogenization (X1), time of homogenization (X2), and enzyme content (X3) with three levels for each variable. While the dependent variables were the apparent viscosity, color expressed as L*, a*, b* values and sensory analysis

Table 4. Central composite design for optimizing condition to rice milk production and responses of physical properties.

| Run number | Variable levels | Response variables |
|------------|-----------------|--------------------|
| X1 | X2 | X3 | Y1 | Y2 | Y3 | Y4 |
| 1   | 0   | 0   | 7.37 | 3.52 | 0.1 | -0.03 |
| 2   | +1  | +1  | 6.95 | 3.73 | 0.19 | 0.12 |
| 3   | -1  | +1  | 6.75 | 3.02 | 0.46 | 0.25 |
| 4   | 0   | -1  | 7.56 | 2.91 | 0.06 | 0.48 |
| 5   | -1  | +1  | 7.75 | 2.43 | 0.64 | 0.14 |
| 6   | 0   | -1  | 6.90 | 2.79 | 0.31 | 0.34 |
| 7   | 0   | 0   | 7.77 | 2.86 | 0.08 | 0.26 |
| 8   | +1  | 0   | 7.93 | 1.8  | 0.18 | -0.02 |
| 9   | 0   | 0   | 7.44 | 2.71 | 0.31 | 0.06 |
| 10  | 0   | +1  | 5.83 | 2.56 | 0.07 | 0.13 |
| 11  | -1  | -1  | 7.13 | 1.98 | 1.37 | 0.3  |
| 12  | 0   | 0   | 5.72 | 2.11 | 0.7  | 0.2  |
| 13  | -1  | -1  | 6.83 | 2.09 | 1.4  | -0.18 |
| 14  | 0   | 0   | 7.76 | 1.68 | 0.68 | -0.08 |
| 15  | -1  | 0   | 7.96 | 1.96 | 1.24 | -0.18 |
| 16  | +1  | -1  | 6.95 | 1.88 | 0.73 | -0.44 |
| 17  | 0   | 0   | 6.61 | 1.71 | 0.69 | -0.57 |
| 18  | 0   | 0   | 7.22 | 1.78 | 0.93 | -0.23 |
| 19  | +1  | -1  | 7.84 | 1.51 | 0.71 | -0.32 |
| 20  | +1  | +1  | 7.65 | 1.91 | 0.05 | 0.05 |

X1= Speed of homogenization (rpm), X2=Time of homogenization (minutes), X3= enzyme content (g) Y1=Viscosity (pa.s), Y2=Color L*, Y3= Color a*, Y4=Color b*
Table 5. Central composite design for optimizing condition to rice milk production and responses of sensory analysis.

| Run number | X1  | X2  | X3  | Y5  | Y6  | Y7  | Y8  |
|------------|-----|-----|-----|-----|-----|-----|-----|
| 1          | 0   | 0   | 0   | 4.45| 6.59| 3.82| 4.3 |
| 2          | +1  | +1  | +1  | 6.49| 6.58| 3.26| 3.78|
| 3          | -1  | 0   | -1  | 4.05| 6.73| 4.27| 4.1 |
| 4          | 0   | 0   | 0   | 5.95| 6.5 | 3.16| 3.94|
| 5          | -1  | +1  | +1  | 6.55| 6.87| 3.49| 4.01|
| 6          | 0   | -1  | 0   | 3.86| 6.73| 3.47| 4.05|
| 7          | 0   | 0   | 0   | 4.39| 6.76| 3.62| 4.16|
| 8          | +1  | 0   | 0   | 4.41| 6.53| 3.68| 4.09|
| 9          | 0   | 0   | 0   | 4.47| 6.26| 3.72| 3.91|
| 10         | 0   | +1  | 0   | 4.85| 6.27| 3.88| 4.56|
| 11         | -1  | -1  | -1  | 2.13| 6.58| 4.19| 4.25|
| 12         | 0   | 0   | 0   | 4.67| 6.64| 3.91| 4.16|
| 13         | -1  | -1  | +1  | 6.54| 6.28| 3.25| 4.01|
| 14         | 0   | 0   | -1  | 2.65| 6.59| 4.12| 4.39|
| 15         | -1  | 0   | 0   | 4.59| 6.59| 3.79| 4.18|
| 16         | -1  | 0   | -1  | 6.75| 6.53| 2.98| 3.54|
| 17         | 0   | -1  | 0   | 4.33| 6.39| 3.72| 4.06|
| 18         | 0   | 0   | 0   | 4.38| 6.63| 3.85| 4   |
| 19         | +1  | 0   | 0   | 2.24| 6.08| 4.05| 4.06|
| 20         | +1  | +1  | -1  | 2.19| 6.29| 3.71| 4.09|

X1 = Speed of homogenization (rpm), X2 = Time of homogenization (minutes), X3 = enzyme content (g), Y5 = Bitterness, Y6 = Smoothness, Y7 = Roughness, Y8 = Aftertaste

The quadratic model suggested from program and used for optimization and explanation of parameters effecting rice milk properties. Three independent variables did not affect the physical properties of the milk, in terms of the viscosity and the color L * b * values and the sensory analysis of smoothness and aftertaste. In contrast, three factors affected color as a * value and sensory analysis of bitterness and roughness significantly (p≤0.05). From the results of regression analysis, the mathematical models for Color a* value (Y3), bitterness (Y5) and roughness (Y7) as functions of speed of homogenize (rpm) (X1), time of homogenize (min) (X2) and content of enzyme (g) (X3) can be expressed by the following equation.

\[ Y_3 = 0.43 - 0.32x_1 - 0.31x_2 + 0.062x_3 + 0.059x_1x_2 - 60250E-003x_1x_3 + 0.034x_2x_3 + 0.35x_1^2 - 0.17x_2^2 + 0.072x_3^2 \]
\[ Y_5 = 4.67 - 0.18x_1 + 0.26x_2 + 1.88x_3 - 0.28x_1x_2 + 0.24x_1x_3 - 0.27x_2x_3 - 0.5x_1^2 - 0.65x_2^2 + 1.18x_3^2 \]
\[ Y_7 = 3.70 - 0.13x_1 + 0.067x_2 - 0.38x_3 - 0.047x_1x_2 + 0.025x_1x_3 - 0.098x_2x_3 + 0.15x_1^2 + 0.092x_2^2 - 0.32x_3^2 \]

3.3. Analysis of response surface graphs
Factors affecting a * values were speed and time of homogenization. From the figure (1A), it showed that when the time and speed of homogenization increased, color a * value decreased. Consistent of Park et al. [30] who found high pressure homogenized decreased both the a* and b* values of the natural plant-based model emulsion and homogenization reduced the fat granules and helped dispersion. When the amount of fat pellets increased, it caused more light reflection, resulting in lighter color [31]. The color of the sterilized milk can occur from Maillard reaction between free amino acids and reducing sugar at high temperature.
Figure 1. Response surface plots. (A) Speed of homogenize and Time of homogenize on color a *values, (B) Speed of homogenize and content of enzyme on sensory evaluation of bitterness, (C) Time of homogenize and content of enzyme on sensory evaluation of roughness.

The content of enzymes and the speed of homogenization affected to bitterness. Figure (1B) showed that as enzyme content increased, bitterness increased. In contrast, when the speed of homogenization increased, the bitterness was decreased. This can be due to that the neutrase is an endoprotease and can produce free amino acids or short peptides that have hydrophobic amino acid residues. Therefore, nonpolar amino acid residues at the C- terminus of the resulting peptides remain and cause a relatively high bitterness[32,33,34]. Zhang et al. and Wang et al.[35,36] found a higher DH at higher content of enzyme to substrate is due to the increase of the contact chance of enzyme and protein and enhanced concentration of peptide bonds from hydrolysis by the proteases. Hence more content of enzyme, more hydrophobic amino acid residues relatively with bitterness of the product.

Enzyme content and the time of homogenization affected roughness. Figure (1C) showed that when the content of enzyme and the time of homogenization was increase, the roughness decreased. This could be that the enzyme could break the peptide bond to a free amino acid or short chain peptide, which would increase interactions between the hydrophilic amino acids and water molecules also can induce changes in the balance of net charges that lead to enhanced solubility [37]. Therefore, the high of enzyme content effect more enzymatic hydrolysis resulting in protein more solubility and less roughness. Jingqi Yang et al. [38] found the homogenization was demonstrated to modulate the hydrophobic interactions among protein aggregates, leading to dissociation of large protein aggregates into soluble
supramolecular aggregates that due to can decrease aggregate size of protein, the solubility of protein increase. Hence, selection of speed and time of homogenization and content of enzyme is importance to produce rice milk with good acceptability. The optimum condition for sterilized rice milk production was found to be at 16000 rpm, 20 minutes of homogenization and 1:40 (w/w) of enzyme to protein.

3.4. Validation of the optimized conditions
In order to confirm the optimized conditions. This optimum conditions from RSM optimization approach was used to validate experimentally shown in Table 6. All predicted and experimental values corresponded very well showed the adequacy of selected models. After the validation process, optimized conditions use to produce rice milk product.

### Table 6. Predicted and experimental values of responses for rice milk production using optimum process parameter.

| Response variable | Predicted values | Experimental values |
|-------------------|------------------|---------------------|
| a* value          | -0.130956        | -0.12333            |
| Bitterness        | 2.61882          | 2.78±2.07           |
| Roughness         | 3.80658          | 3.92±1.37           |

3.5. Proximate analysis
The proximate analysis of rice milk product produced from the optimum condition had 3.14 % protein, 3.28% fat, 0.45% fiber, 0.44% ash, and 5.84%carbohydrate. It also contained 157.3 mg of calcium. The nutritional value of rice milk formulated in this study was like that of cow’s milk and better than rice milk beverages commercial in Thailand as shown in Table 7.

### Table 7. Chemical composition of cow’s milk, rice milk and rice milk commercial in Thailand (g/100ml).

| Chemical composition | Cow’s milk | Rice milk formulated | Rice milk beverages commercialized in Thailand |
|----------------------|------------|----------------------|-----------------------------------------------|
| Protein              | 2.9-5.0    | 3.14 ± 0.02          | 0.4-2.0                                       |
| Fat                  | 2.5-6.0    | 3.28 ± 0.13          | 1.0-1.8                                       |
| Fiber                | -          | 0.45 ± 0.03          | 0.0-4.4                                       |
| Ash                  | 0.6-0.9    | 0.44 ± 0.02          | -                                             |
| Moisture             | 85.5-89.5  | 86.85 ± 0.04         | 52.0-86.0                                     |
| Carbohydrate         | 3.6-5.5    | 5.84 ± 0.04          | 2.28-13.6                                     |
| Calcium (mg)         | 113-125    | 157.3                | 0.0-80.0                                      |

*source nutrition value of cow’s milk [39].
Proximate analysis of rice milk.
rice milk commercial was explored from the market in Thailand.

4. Conclusion
The optimum condition for rice milk production was found to be at 16000 rpm, 20 minutes of homogenization and 1:40 (w/w) of enzyme to protein. The rice milk produced from this condition had nutrition value similar to cow’s milk and better than rice milk beverages commercial in Thailand.
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