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Development of Modified Glutinous Rice Powder by the Pregelatinization Method to Improve the Quality of Cooked High Amylose Rice

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Abstract This research aimed to development modify glutinous rice powder by a pregelatinization method in a drum dryer to improve the physical quality of cooked high amylose rice (Sao Hai rice). Appropriate conditions in the pregelatinization method were studied, 2 factors in the study were gelatinization temperature modified at 3 levels of 120, 130, and 140°C, and the drum dryer speed modified at 2 levels of 1 and 2 rpm. Factorial in Completely Randomized Design (CRD) was used to design the experiment. The modified glutinous rice powder was subjected to physical, chemical, and microbial quality analysis. Next, appropriate conditions were studied for cooking using modified glutinous rice powder. Two factors in the study were the amount of modified glutinous rice powder, at 2 levels of 10% and 15%, and the time spent soaking the rice, at 2 levels of 20 and 30 minutes. The experiment was designed using factorial in CRD. Consumer acceptance of the modified glutinous rice powder was tested among 100 people. The experimental results revealed that the appropriate condition for modifying glutinous rice powder using the pregelatinization method was a gelatinization temperature of 130°C and a drum dryer speed of 2 rpm. In terms of physical quality, the water activity (a_w) of the obtained modified glutinous rice powder was 0.26. With regard to chemical quality, amylose and amylopectin contents were 5.81% and 94.1%, respectively. In terms of microbial quality, the total plate count, yeast and mold met standards of dried food. The appropriate condition for using the modified glutinous rice powder to cook Sao Hai rice required 15% of modified glutinous rice powder with 30 minutes of soaking the rice. The overall consumer acceptance score was very high.

Keywords: *modified flour, Glutinous Rice, pregelatinization, Sao Hai Rice, drum dryer*

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1. Introduction

Rice has been an important grain and food resource for the world's population, especially people living in Asia and the Middle East, Africa and other countries where rice is a staple food. Therefore, rice is a significant crop with a wide impact on the world's population. Since the culture and taste of rice consumption in each region of the world are different, it has been expected that in the long term, the trend of rice consumption will increase, while marketing demands seem to be more complex due to the growth of urban society and middle-class people, which will increase the demands for quality rice, requiring a variety of nutritional values and safety, while the demands for poor-quality rice will decrease. In general, consumer acceptance and preference have been taken into account in terms of the quality of cooking and consumption. The textural properties of cooked rice are very important to its eating quality as they affect its acceptance by consumers [1,2]. The textural properties of rice is controlled by its amylose content. Rice high in amylose content like Oryza sativa (Sao Hai) becomes fluffy when cooked, perfectly separated without forming lumps, and when chewed, its unique rice texture can be experienced [3]. If the hardness of the cooked rice is reduced, it will help people who prefer soft rice to be able to eat this type of rice. Currently, improvement of the physical quality of rice is one of the simplest ways to add more value to rice products, i.e., aromatic pandan semi-cooked rice which pandan leaves contain 2-acetyl-1-pyrroline as those found in cooked jasmine rice, rice coated with herbs, etc.

Pregelatinization is a method of modification of rice flour using heat to form complete gelatinization before drying. Heat in the modification method contributes to changes in flour properties that can meet some requirements, such as water absorption capacity, increase in viscosity when

reheated, heat stability, texture improvement, and cold-water solubility. Consequently, the researcher had an idea to modify glutinous rice flour using the pregelatinization method in a drum dryer to improve the physical quality of cooked high-amylose rice, making it softer, with greater aroma, while causing the rice grains to stick to each other nicely. These changes are intended to make rice with good physical quality accessible to medium- to low-income consumers, encouraging increased consumption of high-amylose rice and adding more value to sticky rice.

This research aimed to modify glutinous rice powder to improve the physical quality of cooked high-amylose rice; to study the physical, chemical, and microbial quality of modified glutinous rice powder; to study appropriate conditions for using modified glutinous rice powder to cook rice; and to study consumer acceptance of the use of modified glutinous rice powder to cook high-amylose rice.

2. Materials and Methods

2.1. Materials

The high-amylose rice used in this research was was Sao Hai (*Oryza sativa*) from Sao Hai district, Saraburi Province, Thailand harvested in December.

The glutinous rice variety used to produce pregelatinized flour was Kiew Ngu (*Oryza sativa var. glutinosa*) from Mae Chan district, Chiang Rai Province, Thailand, as it has long grains and a rich white color. When it is cooked, it forms a sticky lump but is not mushy; it is shiny, soft and aromatic. Kiew Ngu glutinous rice is rich in antioxidants in the form of a high content of vitamin E. It assists the body during the digestive process and can lower cholesterol. It contains gamma (g-oryaznal), which helps reduce oxidation; that is, it helps reduce compounds harmful to cells in blood vessels (endothelial cells).

2.2. Preparation of Fragrant Pandan Juice

Fragrant pandan leaves (*Pandanus amaryllifolius*) were washed to remove dirt, cut into 1-inch long pieces, blended to a 1:1 ratio of the pandan leaves and water in a blender for 2 minutes, and strained through a fine sieve to obtain fragrant pandan juice.

2.3. Preparation of Mixture Glutinous Rice Slurry

Kiew Ngu glutinous rice was mixed with water and fragrant pandan juice to a 2:47:1 ratio and boiled at 100°C for 20 minutes, continued with passing the mixture slurry into blending and then blended for 5 minutes. Its viscosity was measured using a Brookfield viscometer. The viscosity should range between 3600 and 3800 centipoises [4].

2.4. Pregelatinization Process

Mixture Glutinous rice slurry prepared as described in section 2.3 was studied under appropriate conditions for pregelatinization in a drum dryer. There were 2 factors in the study, as the pregelatinization temperatures were set at 3 levels: 120, 130, and 140°C, and the drum dryer speed, which was modified at 2 levels: 1 and 2 rpm. The distance between the drum dryers was 0.3 mm. A factorial in CRD was used to design the experiment to obtain 6 conditions of production. Mixture glutinous rice slurry was produced according to the required temperature and drum dryer speed. The collected modified glutinous rice sheets were milled, passed through a 80-mesh size sieve. Sample were kept in aluminium foil bag and stored at 4°C until obtained for quality analysis as follows:

2.4.1. Water Activity (a_w)

Water activity (a_w) was measured base on the method described by Cuevas-Rodriguez [5]. For measuring water activity, headspace equilibrium was first attained before 5g. of pre-gelatinized glutinous rice flour was tempered at 25°C using Water Activity Reader AquaLab CX3TE. Reading were then taken in triplicates.

2.4.2. Color Measurement

Color of six samples were measured by Hunter Lab Colorimeter (Model 45/O-S, Hunter Associates Laboratory Inc., VA, USA). Color values were recorded as L* (lightness) a* (redness when positive and greeness when negative) and b* (yellowness when positive and blueness when negative). Analysis were performed in triplicate [10].

2.4.3. Water Solubility Index (WSI) and Water Absorption Index (WAI)

Water solubility index and water absorption index were performed using the modified Anderson method [6]. A 0.8g. sample was weighed and placed in a centrifuge tube to determine the specific weight. 10 ml. of distilled water was added and mixed together, stirred every 5 minutes for 30 minutes and put in a centrifuge at 3,000 rpm for 10 minutes. The obtained clear solution was contained in an aluminum cup to determine the specific weight, oven dried at 135°C for 8 hours and cooled in a desiccator. Its weight was recorded, and the remaining sediment at the bottom of the tube was weighed to calculate the water solubility index (WSI) according to Eq. (1) and the water absorption index (WAI) according to Eq. (2):

$$WSI = \frac{\begin{pmatrix} weight\ of\ the\ flour \\ that\ was\ soluble\ in\ water \end{pmatrix}}{weight\ of\ the\ sample\ used\ in\ the\ analysis} \times 100 \quad (1)$$

$$WAI = \frac{\begin{pmatrix} weight\ of\ the\ flour\ sediment \\ after\ centrifugation \end{pmatrix}}{weight\ of\ the\ sample\ used\ in\ the\ analysis} \quad (2)$$

Appropriate conditions were selected by considering the water activity of products must not be greater than 0.6, production conditions having the highest water solubility index, production conditions having the lowest water absorption index.

2.5. The Quality of Modified Glutinous Rice Powder

Modified glutinous rice powder was produced according to the appropriate conditions mentioned in point from 2.4,

and the physical, chemical, and microbial qualities were analyzed.

Physical quality was water activity (a_w) measured base on the method described by Cuevas-Rodriguez [5]. For measuring water activity, headspace equilibrium was first attained before 5g. of pre-gelatinized glutinous rice flour was tempered at 25°C using Water Activity Reader AquaLab CX3TE. Reading were then taken in triplicates.

Chemical quality referred to amylose content and amylopectin content following the standard method proposed by Juliano [7] with minor modification was used for the estimation of amylose content. Modified glutinous rice powder of 100 mg was weighted and taken into 100 ml volumetric flask. It was added with 1 ml 95% ethanol and 9 ml 1 N. NaOH and left overnight. On the Subsequent day distilled water was added to the samples to make up the final volume to 100 ml. Mixed solution of 5 ml from 100 ml was pipetted out into another 100 ml volumetric flask. 1 N acetic acid (1 ml) followed by 2 ml iodide solution were added and the volume was made upto to 100 ml. The content was stirred and allowed to stand for 20 min before absorbance was measured at 620 nm with a UV Spectrophotometer. Amylose concentration was obtained by plotting the absorbance in the potato amylose standard curve. Amylose content of each sample was expressed aspercentage to total quantity of sample taken for analysis.

Microbial quality evaluation included Aerobic plate count and yeast and mold [8]. The preparation of samples for microbiological analysis followed the procedure described in Flour samples (25g) were mixed with 225ml of buffered peptone water in stomacher bags and further homogenized in a stomacker equipment for 1 min at 300 units. The obtained suspensions were further diluted to obtain dilutions from 10^{-1} to 10^{-5}. Each dilution was analyzed in triplicate.

Aerobic plate count (APC analysis): 1 ml of each prepared suspension was mixed with 20 ml of Plate Count Agar by the pour plate method, in triplicate. The plates were further incubated in reversed position at 30°C for 72 h. Visible colonies were counted and calculated.

Yeasts and molds: 0.2 ml of each suspension was spread in petri dishes containing 20 ml of Potato Dextrose Agar, in triplicate. The plates were further incubated in upright position at 25°C for: 72 h for yeast counting and 120 h for mould counting.

2.6. The Conditions for Using Modified Glutinous Rice Powder to Cook Sao Hai Rice

There were 2 factors involved in the study on appropriate conditions for using modified glutinous rice powder to cook Sao Hai rice: the amount of modified glutinous rice powder at 10% and 15% of the weight of high amylose rice, and time spent soaking Sao Hai rice for 20 and 30 minutes. A factorial CRD was used to design the experiment, and 4 production conditions were obtained. The ratio of Sao Hai rice to water was 1:4. Steps for cooking the rice were to dissolve modified glutinous rice powder in the water used for cooking rice, stir until melted, soak Sao Hai rice according to the determined time, cook the rice in an electric rice cooker, and thus cooked Sao Hai rice was obtained compare with Sao Hai rice soaked in plain water 20 and 30 minutes.

The softness of the cooked Sao Hai rice was measured using a texture analyzer through an extrusion test by requiring a speed in the test of 1.6 mm/second, a speed after the test of 10 mm/second, and a distance of 45 mm. The diameter of the texture analyzer probe was 40 mm, and the weight of the cooked Sao Hai rice was 100g.

The 9-point hedonic scale was used for sensory evaluation in terms of appearance, stickiness, overall aroma, softness and overall liking. There were 100 panelists, and appropriate production conditions were considered from the highest score. Before the consumer taked the test, they must filled out a consent form first.

2.7. Consumer Acceptance

The consumer acceptance of using modified glutinous rice powder to cook Sao Hai rice was conducted by testing consumers who ate Sao Hai rice by random -- 100 persons aged from 20 years in Phra Nakhon Si Ayutthaya and Pathum Thani provinces and before testing the product, they must fill out a consent from first -- through a home-use-test method, questionnaire in conjunction with a sample of Modified glutinous rice powder.

2.8. Statistical Analysis

The data were calculated using SPSS software (version 20.0; SPSS (Thailand) Co., Ltd; Bangkok, Thailand). For each analysis, triplicate measurement were analysis of variance (ANOVA) and present as mean ± standard deviation (S.D.). Duncan's multiple rang tests were performed to determine if differences among treatment means were significant at the 95% confidence level ($p < 0.05$).

3. Results and Discussion

3.1. Pregelatinization Process

The results of studying appropriate conditions for modification of glutinous rice powder using the pregelatinization method in a drum dryer. The analysis of physical quality as water activity (a_w) and the three reference values of L*, a* and b* are shown in Table 1, and the results of the water solubility index and water absorption index are shown in Figure 1 and Figure 2.

Table 1 shows that the water activity (a_w) of all 6 production conditions ranged between 0.17 and 0.27, and the water activity (a_w) was below 0.6, which met the standard of dried food products in which water activity (a_w) must not be above 0.6 because water activity is one of the important factors controlling the rate of deterioration of food, which has a direct effect on the stability and shelf life of food. Water activity refers to the amount of water available to a microorganism for its growth [9].

Table 1. Water activity (a_w) and the values of L*, a* and b* of the modified glutinous rice powder

Condition	Temperature (°C), The drum dryer rotation speed (rpm)	a_w	L*	a*	b*
1	120/1	0.19 ± 0.01	63.97^{e} ± 0.56	1.56^{b} ± 0.02	12.42^{bc} ± 0.23
2	120/2	0.27 ± 0.04	65.76^{d} ± 1.58	1.52^{bc} ± 0.05	12.74^{b} ± 0.29
3	130/1	0.17 ± 0.02	74.92^{b} ± 0.24	1.74^{a} ± 0.03	14.09^{a} ± 0.18
4	130/2	0.26 ± 0.03	72.82^{c} ± 0.07	1.70^{a} ± 0.03	13.79^{a} ± 0.15
5	140/1	0.18 ± 0.02	77.02^{a} ± 0.52	1.54^{bc} ± 0.01	12.12^{cd} ± 0.04
6	140/2	0.25 ± 0.01	73.86^{bc} ± 0.40	1.49^{c} ± 0.02	12.02^{d} ± 0.15

Remark: - Different letters in the vertical line mark a statistically significant difference between the means ($p < 0.05$).
- The highest mean was x^{a}, followed by x^{b}, x^{c}, x^{d}…

The L* value, it was found that the modified glutinous rice powder produced from all 6 conditions was statistically significant ($p \leq 0.05$), as in the 5th production condition, the temperature was 140°C, and the drum rotation speed was 1 rpm. This exposed the flour solution to heat for a long time, resulting in an increase in the degree of gelatinization. Gelatinization increased the viscosity and clarity of the flour solution. This was consistent with a study conducted by Chutima [10] that showed that an increase in temperature resulted in a greater luminosity because exposure of food samples to a drum dryer at high temperature brought about gelatinization.

The a* value was negative (-a), showing that the modified glutinous rice powder produced from the 6 conditions had a green color value since pandan leaves were added as its ingredient. Pandan leaves have a high chlorophyll content, a green substance, making the product appear light green [11].

The b* value was positive (+b), showing that the modified glutinous rice powder produced from the 6 conditions had a yellow color value since heat was required in the drum drying process. The heating process contributed to the darker color of the flour, as the powder of pregelatinized glutinous rice flour contained glucose compounds that resulted in burning when heated and made a caramelization reaction, which caused a change in the flour molecules, producing a noticeable brown color [12].

The results from studying the water solubility index are shown in Figure 1.

Figure 1 indicates that the modified glutinous rice powder from all 6 conditions had significantly different water solubility index values ($p \leq 0.05$), and the 4th production condition (130°C /2 rpm) gave the highest water solubility index.

The results from studying the water absorption index are shown in Figure 2.

Figure 2 shows that the water absorption index of the modified glutinous rice powder in a drum dryer under all 6 production conditions was significantly different ($p \leq 0.05$), and the 4th production condition (130°C/2 rpm) gave the highest water absorption index.

The findings from the experiment revealed that the water absorption index increased with increasing temperature from 120 to 130°C but decreased when the temperature was 140°C. This was in harmony with the study conducted by Klanarong and Kueakun [12] found that an increase in temperature led to an increase in the water absorption index. However, when the flour continued to be heated beyond the gelatinization temperature, the flour swelled further until it reached the maximum swelling and broke down into smaller molecules of amylose and dispersed, reducing viscosity. When the flour was cooled down, amylose molecules close to each other arranged new formations by hydrogen bonding among molecules, giving rise to a 3D network. This new structure could hold water and did not absorb water again with an increase in viscosity and sticky gel, similar to a film or crystal known as retrogradation, which refers to the occurrence in which starch reverts or retrogrades to a more crystalline structure upon cooling.

Therefore, the appropriate condition for drum drying the modified glutinous rice powder for cooking Sao Hai rice was the 4th production condition (130°C /2 rpm) since it gave the highest water solubility index and the lowest water absorption index, making the instant glutinous rice powder dissolve well in water and making it a practical product for cooking Sao Hai rice.

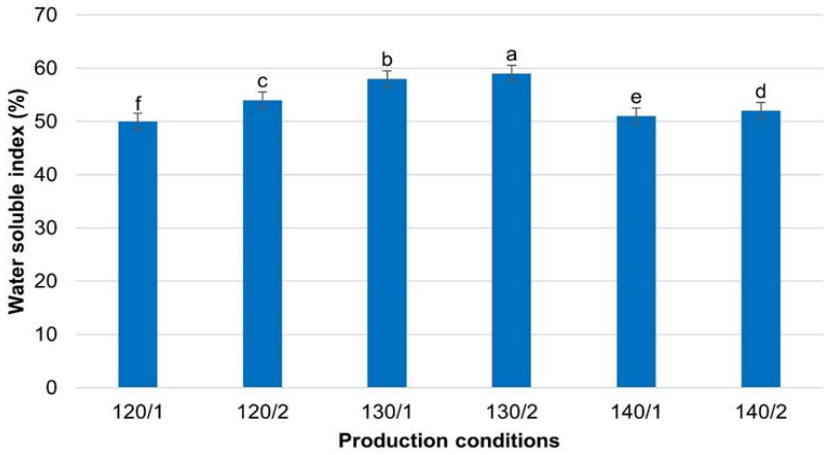

Figure 1. Water solubility index of the modified glutinous rice powder (Remark: Different letters indicated a statistically significant difference between the mean ($p \leq 0.05$))

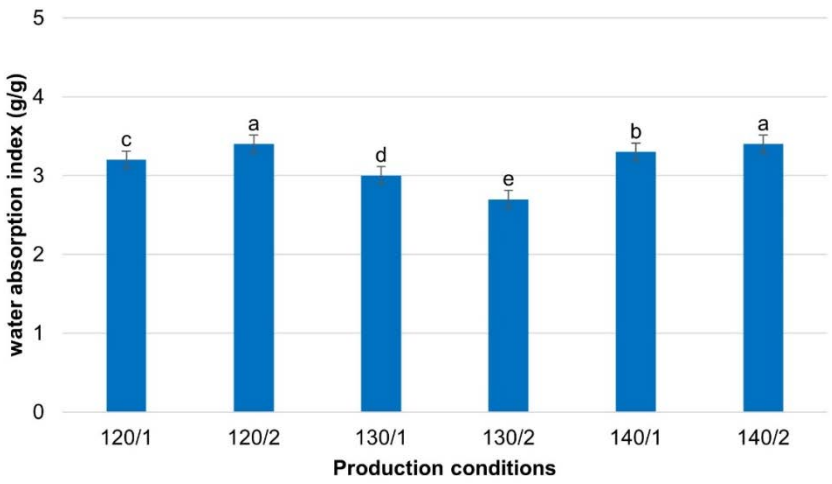

Figure 2. Water absorption index of the modified glutinous rice powder (Remark: Different letters indicated a statistically significant difference between the mean ($p \leq 0.05$))

3.2. The Quality of Modified Glutinous Rice Powder

Modified glutinous rice powder was produced according to the appropriate conditions in section 3.1 and the physical, chemical and microbial qualities were analyzed. The results are shown in Table 2.

Table 2. Physical, chemical, and microbial qualities of the modified glutinous rice powder

Quality	Content
Physical quality	
- Water Activity (a_w)	0.26
Chemical qualities	
- Amylose content (%)	5.81
- Amylopectin content (%)	94.19
Microbial qualities	
- Total microorganism count (CFU/g)	<10
- Total yeast and mold counts (CFU/g)	<10

Based on Table 2, the physical quality analysis of the modified glutinous rice powder indicated that the water activity (a_w) was 0.26, which met the standard of dried food products that the water activity (a_w) must not be greater than 0.6.

Chemical quality analysis of modified glutinous rice powder found a 5.81% amylose content and 94.19% amylopectin content. This was consistent with a study conducted by Piyaphon [13] found that the amylopectin content had effect on softness and stickiness of rice. This characteristic is therefore suitable to be used to improve the physical quality of the rice.

The microbial quality analysis of the modified glutinous rice powder found that the total microorganism count was less than 10 CFU/g and the total yeast and mold counts were less than 10 CFU/g, showing that the modified glutinous rice powder met the standard, which specifies that the total microorganism count should not be greater than $1x10^4$ colonies per gram of sample and that the total yeast and mold counts should be fewer than 100 colonies per gram of sample. The microbial quality analysis indicated that the modified glutinous rice powder was hygienic and safe for consumption.

3.3. The Conditions for Using Modified Glutinous Rice Powder to Cook Sao Hai Rice

There were 2 factors in studying appropriate conditions for using the modified glutinous rice powder to cook Sao Hai rice. The amount of the modified glutinous rice powder at 2 levels as 10% and 15%, and time spent soaking the rice, modified at 2 levels as 20 and 30 minutes. The experiment was designed using factorial in CRD. Appropriate conditions were selected by texture measurement, and consumer acceptance of the modified glutinous rice powder product was tested among 100 people. The study results are shown in Table 3 and Table 4.

Table 3. Hardness of cooked Sao Hai rice

Condition	The amount of modified glutinous rice starch (%)	Time spent on rice Soaking (min)	Hardness (kg).
1	10	20	$0.88^b \pm 0.11$
2	10	30	$0.84^c \pm 0.09$
3	15	20	$0.86^b \pm 0.25$
4	15	30	$0.64^d \pm 0.12$
5	Not addition of modified glutinous rice starch	20	$0.95^a \pm 0.25$
6	Not addition of modified glutinous rice starch	30	$0.94^a \pm 0.15$

Remark: Different letters in the vertical line mark a statistically significant difference between the means ($p \leq 0.05$).

From Table 3, it was found that hardness was significantly different ($p \leq 0.05$). Namely, the 4th production condition that used 15% modified glutinous rice powder with the rice soaked for 30 minutes had the lowest level of hardness equal to 0.64 kg. The result indicated amount of the modified glutinous rice powder and time for soaking to be correlated with the textural qualities of cooked rice because the modified glutinous rice powder had high amylopectin content which then impacted the texture, resulting in lower hardness and higher stickiness [14].

Table 4. The mean liking scores towards characteristics of Sao Hai rice cooked with the modified glutinous rice powder

The amount of modified glutinous rice starch (%)	Time spent on rice soaking (minute)	Characteristics				
		appearance	stickiness	Overall aroma	softness	Overall liking
10	20	5.92^{d}± 1.65	5.90^{c}± 1.10	7.30^{a}± 1.23	6.44^{c}± 1.16	6.88^{c}± 1.15
10	30	6.86^{c}± 1.85	6.84^{b}± 1.16	7.72^{a}± 1.19	7.00^{b}± 1.30	7.14^{b}± 1.19
15	20	7.26^{b}± 1.29	7.54^{a}± 1.27	7.80^{a}± 1.14	7.00^{b}± 1.25	7.24^{b}± 1.23
15	30	8.74^{a}± 1.15	7.96^{a}± 1.10	7.56^{a}± 1.06	7.52^{a}± 1.11	7.78^{a}± 1.08
0	20	5.80^{d}± 1.23	5.50^{c}± 1.27	5.42^{b}± 1.21	4.90^{d}± 1.05	5.82^{d}± 1.13
0	30	6.00^{d}± 1.73	5.80^{c}± 1.57	6.14^{b}± 1.01	5.10^{d}± 1.05	6.12^{d}± 1.31

Remark: Different letters in the vertical line mark a statistically significant difference between the means ($p \leq 0.05$).

From Table 4, the 9-point hedonic scale was used to evaluate sensory liking in terms of appearance, stickiness, overall aroma, softness, and overall liking from 100 consumers to select appropriate production conditions by considering overall liking scores in all aspects. There were statistically significant differences ($p \leq 0.05$) in the means of appearance, stickiness, overall aroma, softness and overall liking. Consumers gave the highest liking scores to all aspects of Sao Hai rice cooked by using 15% modified glutinous rice powder with 30 minutes of rice soaking. This was consistent with a research study conducted by Kasem [15] that found that consumers' liking was associated with rice characteristics in terms of softness, stickiness, and aroma of cooked rice. Based on the study, fragrant pandan juice was added to modified glutinous rice powder. The fragrance in jasmine rice is 2-acetyl-1-pyrroline or 2AP, which is similar to the smell of pandan leaves and the modified glutinous rice powder in cooking water increased softness (reduced hardness according to result in Table 3) and stickiness.

3.4. Consumer Acceptance

The survey on the acceptance of using modified glutinous rice powder to cook Sao Hai rice was conducted by testing among 100 consumers aged from 20 years who ate Sao Hai rice in Phra Nakhon Si Ayutthaya and Pathum Thani provinces through a home-use-test method, questionnaire in conjunction with a sample of modified glutinous rice powder. The findings from the survey revealed the following, most consumers were satisfied with the rice cooking method using modified glutinous rice powder to improve the quality of Sao Hai, and the consumer acceptance score overall was very high, 71.00%, since the obtained cooked rice had softness, stickiness, and a nice aroma similar to cooked jasmine rice. 68.00% of consumers accepted the rice cooking method using modified glutinous rice powder. The greatest problem found in using modified glutinous rice powder was the long time spent soaking the rice, accounting for 43.00%. Regarding the product distribution of the modified glutinous rice powder for cooking Sao Hai rice, 75.00% of consumers were interested in buying the product, and 78.00% suggested that the product should be available at convenience stores.

4. Conclusion

The appropriate condition for modification of glutinous rice powder using drum dryer for pregelatinization was a 130°C and speed was 2 rpm. The physical, chemical, and microbial quality of modified glutinous rice powder as the water activity (a_w) was 0.26, the amylose and amylopectin contents were 5.81 and 94.19, respectively, while the total plate count and yeast and mold counts were less than 10 CFU/g. For the study on appropriate conditions for using the modified glutinous rice powder for Sao Hai rice cooking were 15% modified glutinous rice powder and 30 minutes for soaking. In relation to the study on satisfaction and acceptance of using modified glutinous rice powder to cook Sao Hai rice among 100 consumers, it was found that the consumer acceptance score overall was very high.

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References

[1] Wada, M. Tsubone, Y. Hamanhi and Ogata, T. "Evaluation and use of physicochemical properties as index trains for selecting rice cultivars with extremely high palatability," *Japanese Journal of Crop Science*, 75(1), 38-43, 2006.

[2] Lyon, B.G. Champagne, E.T. Vinvard, B.T. andWindham, W.R. "Sensory and instrumental relationships of texture of cooked rice from selected cultivars and postharvest handling practices," *Cereal Chemistry*, 77(1), 64-69, January 2000.

[3] Luechai, A. and Anchali, P. "Chek Shuey Kaab Keaw Sao Hai Rice," *Kasikorn News*, 79(4), 9-13, 2006.

[4] Vallous, N.A. Gavrielidou, M.A. Karapantsios T.D. and Kostoglou, M. "Performance of a double drum dryer for producing pregelatinized maize starches," *Journal of Food Engineering*, 51(3), 171-183, February 2002.

[5] Cuevas-Rodriguez, E.O. Verdugo-Montoya, N.M. Angulo-Bejarano, P.I. Milam-Carrillo, J. Mora-Escobedob, R. and Bello-Perez, L.A. "Nutritional properties of reknown flour from quality protein maize (Zea Mays L)," *LWT, Food Science Technology*, 39, 1072-1079, December 2006.

[6] Anderson, R. A. Conway, H. F. Pfeifer, V. F. and Griffin, E. L. "Gelatinization of corn grits by roll and extrusion cooking," *Cereal Science Today*, 14, 4-12, 1969.

[7] Juliano, B.O. Perez, C.M. and Blakeney, A.B. "International Cooperative testing on the amylose content of milled rice," *Starch*, 33(5): 157-162, 1981.

[8] AOAC, Official methods of analysis (21st ed.), Association of Official Analysis Chemistry, Washington DC, 2019.

[9] Nitaya, R. Basic Food Processing, Odeon Store, Bangkok, 21-23, 2001.

[10] Chutima, A. Comparative Study on Instant Powder Quality of Lemongrass (Cymbopogon citratus Stapf) Obtained from Drum Dying and Foam-Mat Drying [Research]. Phitsanulok: Naresuan University. 2008.

[11] Panorjit, N. Oranut, S. Suphachai, P. and Nirun, N. Yanang Processing Powder and Application in Food Product [Research]. Nakhon Ratchasima: Rajamangala Univerity of Technology Isan. 2015.

[12] Klanarong, S. and Kueakun, P. Starch Technology (4th ed.). Bangkok: Kasetsart University Press. 2007.

[13] Piyaphon, S. Characterization of Physicochemical Properties of Glutinous Rice and Mixed Glutinous-Hom-Mali Rice Flour and Their Utilization for Butter Cake [Research]. Bangkok: Kasetsart University. 2011.

[14] Wada, T. Umemoto, T. Aoki, N. Tsubone, M. Ogata, T. and Kondo, M. "Starch Eluted from Polished Rice during Soaking in Hot Water is Related to the Eating Quality of Cooked Rice," *Journal of Applied Glycoscience*, 58(1), 13-18, 2010.

[15] Kasem, N. Suchada, L. Ratchada, T. and Wichien, V. "Optimized formulation and cooking conditions of Khaw Dawk Mali 105 and Chainat 1 mixed rice," *KKU Research Journal*, 8(1), 20-33, 2003.