Development of Rice Forming using Konjac Flour Mixed with RD43 Rice Flour as Main Components

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Abstract. *The aim of this project is to study the effect of mixture ratio and screw conveyor speed on capacity and quality of konjac rice product after drying. There were 3 levels of screw conveyor speeds of 5.63, 6.23 and 6.77 rpm. The mixing ratio of RD 43 rice to konjac flour was 3 levels of 7:2, 6.5: 2.5 and 6:3. The drying temperature of 70 Celsius degrees was used for 30 minutes to dry the konjac rice product (water activity lower than 0.6). After that, the qualities of the konjac rice product including size, color values i.e. L* a* b* and whiteness index, hardness and stickiness of cooked konjac rice product as well as sensory assessment were analysed. Result indicated that increase in the screw conveyor speed resulted in increasing product length. When considering in mixing ratio, the brightness, the whiteness index and stickiness of cooked konjac rice product decreased when RD43 rice ratio was decreased. For sensory evaluation by hedonic test, the overall liking score of mixing ratio of RD 43 rice to konjac flour of 7:2 had the highest value at 6.90. The screw conveyor speed at 6.23 rpm was recommended for production of konjac rice product.*

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1. Introduction

Konjac gluomannan (KGM) is a neutral polysaccharide extracted from the tuber of Amorphophallus muelleri and cultivated in several parts of Asia. KGM has been consumed for nearly 2000 years in Asia [1],[2]. It presents excellent functional properties and is claimed as a low-calorie ingredient due to its non-digestible fiber compound to aid in weight loss. It might also slow the absorption of sugar and cholesterol in the gut, helping to control sugar levels in people with diabetes and reduce cholesterol levels [3],[4]. Therefore, KGM has a great potential to be developed as a functional food with various health benefit [5]. KGM has been used as emulsifier and stabilizer in food, drinks, and cosmetic products due to its gelling properties and incomparable rheological [6]. Moreover, KGM can be used as drug delivery and used with controlled release properties, bioadhesive properties, and cellular therapy [7].

RD43 is one of Thailand's achievements for white rice with the medium to low glycemic index value (or GI). It allows your body to slowly digest absorbs and metabolizes it into the optimal blood glucose level – may help in controlling blood sugar level. The texture of cooked RD43 rice is soft and finest quality [8],[9].

The mixing between RD43 rice flour and konjac flour to make a new product called konjac rice is possibly developed. Rice forming machine was designed and constructed by staff of Faculty of Engineering, Mahasarakham University. This machine can be used to form the imitated rice. There are many factors affecting the yield, size, shape and appearance of imitated rice i.e. cutting blade, blade type, roller speed, screw conveyor speed.

Therefore, we are interested to produce the healthy food by mixing RD43 rice flour with konjac flour to create alternative product for health-conscious consumer. The factor in this study is screw conveyor speeds of rice forming machine and ratio of RD 43 rice to konjac flour.

Ingredient	Formula		
	1	2	3
RD43 rice flour (g)	70	65	60
Konjac flour (g)	20	25	30
Tapioca four (g)	5	5	5
Potato flour (g)	5	5	5
Water (ml)	100	105	110

Table 1 forming rice from different formulas

2. Material and Method

2.1 Mixture Preparation

The RD43 rice was purchased from the supermarket and ground to flour with a 80-mesh sieve. The Konjac flour

was purchased from Krungthepchemi Co., Ltd., Bangkok, Thailand. The ingredients and ratio between the RD43 rice flour and the Konjac flour was varied while other ingredients (Tapioca four and Potato flour) was fixed as the same ratios for all the formulas as shown in Table 1. Tapioca and cassava flours were used as binder for mixing. When konjac flour increased, the water content increased due to konjac four could absorb more water than other flours. The ingredients were mixed using dough mixture machine for 15 min to reach the consistency of dough. Then, it was used for rice forming with the machine.

2.2 Rice Forming Machine

The machine was designed and constructed by staff from Faculty of Engineering, Mahasarakham University, Thailand. It is shown in Fig. 1. Dough was fed at the top of the machine. It was extruded by screw conveyor and cut as small piece with the blade. Then, it was fallen into the upper roller to expand as cylinder shape before falling to middle roller. Next, it was squeezed by thread roller with a pitch of 7 mm (same as the length of rice) at a lower position. Sample was collected under the roller.

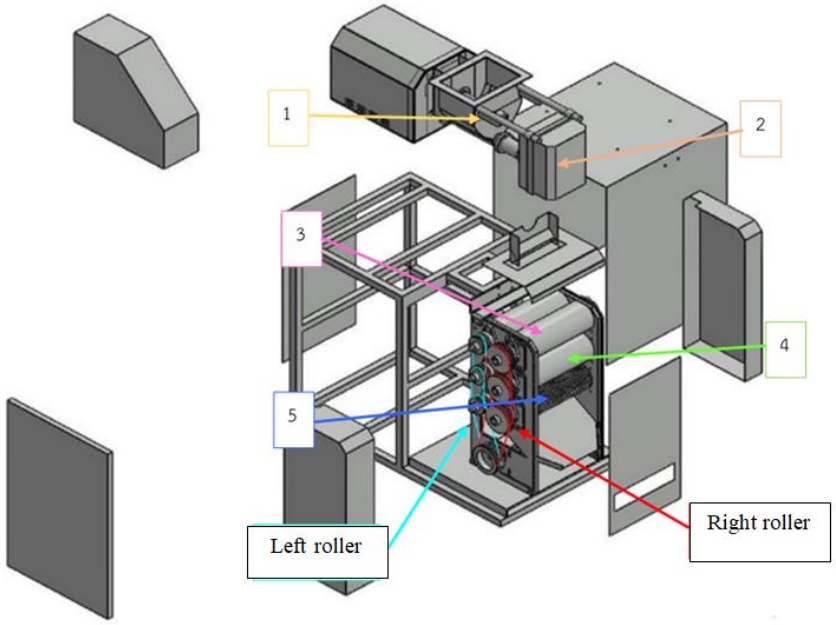

Fig. 1 Schematic of rice forming machine consists of 1) screw conveyor motor 2) blade motor 3) upper roller 4) middle roller and 5) lower roller

2.3 Experimental Procedure

Dough was prepared from 3 different formulas. Then, it was extruded at different speeds of a screw conveyor of 5.63, 6.23 and 6.77 rpm. The screw conveyor speed was adjusted by the inverter. Each condition was tested with the sample approximately 1,000 g of dough mixture. Yield and process time were recorded. The imitated rice was then dried at 70 ^{o}C using tray dryer for 30 min to get the dried sample. After that, it was determined the properties i.e. width, length, color values, cooking properties and sensory evaluation.

2.4 Sample Determination

2.4.1 Dimension of Imitated Rice

Vernier caliper was used for measuring the width and the length of imitated rice after drying. Each treatment was measured for 10 replications.

2.4.2 Color Values

The color of imitated rice was measured by a Hunter Lab Colorimeter (type Color Flex, USA). The Hunter L*, a*, b* scale gave measurement of colors in units of approximate visual uniformity throughout the solid. The L* value measures lightness and varies from 100 for a perfect white and 0 for black, a* and b* when positive measure redness and yellowness, respectively. For whiteness index (WI), it was calculated as following equation.

$$WI= 100-[(100-L)^2 + (a^2 + b^2)]^{1/2} \quad (1)$$

2.4.3 Cooking properties

The imitated rice was cooked with electrical rice cooker. Hardness and stickiness of imitated cooked rice was measured using Texture Analyzer (model TA.XT. Plus) with the probe type rice extrusion rig as shown in Fig. 2. After cooking, sample was left in the rice cooker until the temperature reached down to room temperature. Then, 17 g

of sample was placed in the chamber. The program was set as following. Return distance was set at 160 mm. Return to speed was set at 10 mm/s. Contact force was 10 g. Move probe location was moved for 52 mm which was 3 mm distance to base. After run a test, hardness and stickiness were recorded.

Fig. 2 Measuring cooked Konjac rice texture using rice extrusion rig

2.4.4 Sensory Evaluation

Konjac rice product was cooked with electrical rice cooker. After that, sample 20 g with warm temperature was served for each panelist. Sensory evaluation was performed using hedonic test. Twenty-untrained panelists were employed to give the score for quality attributes including appearance, color, odor, taste, texture and overall liking with 9-point hedonic scale, in which score 9 corresponded to the like extremely and score 1 referred to dislike extremely.

2.5 Statistical Analysis

All measurements were conducted in three replicates and the average of the value was presented as the mean and the standard deviation. The mean comparison from different conditions was analyzed by Duncan's New Multiple Range Test (DMRT) at 5% significance level using SPSS program.

3. Results and Discussion

The yield and process time are illustrated in Table 2. The yield which assessed the unbroken product fallen in the tray. The mixing ratio of RD43 rice to konjac flour of 6.5:2.5 and 6:3 show the not significance higher yield in all screw conveyor speeds compared to the mixing ratio of RD 43 rice to konjac flour of 7:2. However, the process time of different formulas was similar at the same screw conveyor speed. The faster speed, the shorter process time was reported. To produce the konjac rice product, the other aspects in term of quality such as dimension, color, texture are important to assess before choosing the suitable condition.

Konjac rice product is shown in Fig. 3. The appearance was different from milled rice. However, the shape is similar.

Fig. 3 Konjac rice product sample (left) compared to milled rice (right)

Mixing ratio of rice to konjac	Screw conveyor speed (rpm)	Total dough (g)	Yield (g)	Percentage	Process time (min)
7:2	5.63	983.4	819.3 ± 24.8^{d}	83.31	40
	6.23	982.0	813.0 ± 8.3^{cd}	82.79	35
	6.77	983.7	832.0 ± 7.7^{bcd}	84.58	32
6.5:2.5	5.63	1,001.7	846.4 ± 29.3^{abc}	84.50	40
	6.23	1,001.0	845.1 ± 6.9^{abc}	84.43	35
	6.77	997.4	848.9 ± 3.3^{ab}	85.11	32
6:3	5.63	1,018.0	857.0 ± 19.5^{ab}	84.18	40
	6.23	1,022.6	862.3 ± 5.4^{a}	84.32	35
	6.77	1,009.5	864.4 ± 7.1^{a}	85.63	32

Means with the different letter within a column are significantly different ($p \leq 0.05$) by DMRT

Table 2 Yield and process time of forming rice

The width and the length are presented in Table 3 and 4. The width of product is not significantly different by mixing ratio and screw conveyor speed. However, the length is positively increased with the screw conveyor speed. While as the mixture does not affect to the length. This length of konjac rice product is similar to the long grain rice such as 7.2-7.6 mm of Khao Dawk Mali 105, 7.3-7.8 of Pathumthaini 1 [10]. When consider in dimension and process time, the screw conveyor speed of 6.23 rpm was chosen for producing the konjac rice product to compare the quality including color, cooking properties and sensory evaluation at different formulas.

Mixing ratio of rice to konjac	Width (cm)		
	5.63^{ns} (rpm)	6.23^{ns} (rpm)	6.77^{ns} (rpm)
7:2^{ns}	0.16±0.01	0.16±0.01	0.17±0.01
6.5:2.5^{ns}	0.15±0.02	0.17±0.01	0.17±0.01
6:3^{ns}	0.15±0.01	0.16±0.01	0.17±0.01

ns= not significance

Table 3 The width of Konjac rice product

Mixing ratio of rice to konjac	Length (cm)		
	5.63^{ns} (rpm)	6.23^{ns} (rpm)	6.77^{ns} (rpm)
7:2	0.74±0.05^{b}	0.80±0.05^{ab}	0.85±0.03^{a}
6.5:2.5	0.71±0.06^{b}	0.78±0.05^{ab}	0.85±0.04^{a}
6:3	0.75±0.09^{b}	0.79±0.07^{ab}	0.85±0.04^{a}

Means with the different letter within a row are significantly different ($p \leq 0.05$) by DMRT
ns= not significance

Table 4 The length of Konjac rice product

The quality of konjac rice was compared by varying only the mixing ratios. The color values in term of *L** a* b* and WI are shown in Table 5. The L* and WI decreased with increasing of konjac flour. This due to the color of konjac flour is darker than rice flour. Therefore, it affected to the color of final product as the different ratio of flours.

The sample of cooked konjac rice product is shown in Fig. 4. It was easily cooked by rice cooker. By visual assessment, it was similar to normal rice when cooking. The cooking properties of different formulas are different as shown in Table 6. It demonstrated that when the ratio of konjac flour increased the water needed for cooking was also increased since the konjac flour can absorb more water than rice flour. However, the hardness of cooked product was not significantly different. While as the stickiness decreased when the ratio of konjac increased. This might be the textural properties of rice flour is stickier than konjac flour.

Fig. 4 Sample of cooked Konjac rice product

The mean scores from sensory evaluation are shown in Table 7. The panelists assess appearance, color, odor, taste, texture and overall liking. The highest score in all aspects was obtained from the mixing ratio of RD43 rice to konjac at 7:2. This score level means like slightly. To improve the linking of this product, flavor such as 2-acetyl-pyrroline which is an aroma compound of jasmine rice could be applied. The sensory score in all attributes of ratio of RD43 rice to konjac at 6.5:2.5 and 6:3 is not significantly different. This score level refers to neither like nor dislike the cooked konjac rice product.

Mixing ratio of rice to konjac	Color values			
	L*	a*	b*	WI
7:2	83.34±0.51^{a}	0.31±0.04^{c}	10.68±0.41^{b}	80.20±1.22^{a}
6.5:2.5	82.02±0.50^{b}	0.60±0.04^{b}	11.39±0.31^{a}	78.70±0.75^{b}
6:3	80.79±0.31^{c}	0.77±0.02^{a}	11.96±0.16^{a}	77.35±0.57^{c}

Means with the different letter within a column are significantly different ($p \leq 0.05$) by DMRT

Table 5 Color values of konjac rice product after drying

Mixing ratio of rice to konjac	Ratio of rice to water for cooking	Hardness ^{ns} (N)	Stickiness (N.sec)
7:2	1:2.55	33.49±1.13	-12.35±1.24^{c}
6.5:2.5	1:2.60	33.22±1.08	-7.51±0.35^{b}
6:3	1:2.65	33.58±1.13	-4.45±0.46^{a}

Means with the different letter within a column are significantly different ($p \leq 0.05$) by DMRT
ns= not significance

Table 6 Cooking propertied of Konjac rice product

Mixing ratio of rice to konjac	Appearance	Color	Odour	Taste	Texture	Overall liking
7:2	6.65±1.53^{a}	6.55±1.36^{a}	6.60±1.43^{a}	6.55±1.28^{a}	6.40±1.39^{a}	6.90±1.07^{a}
6.5:2.5	4.65±2.03^{b}	5.60±1.67^{ab}	5.20±1.80^{b}	4.75±1.59^{b}	4.35±1.95^{b}	4.85±1.50^{b}
6:3	4.60±1.31^{b}	4.95±1.54^{b}	5.30±1.60^{b}	4.90±1.74^{b}	4.40±1.85^{b}	4.95±1.51^{b}

Means with the different letter within a column are significantly different ($p \leq 0.05$) by DMRT

Table 7 Means score for sensory attributes of cooked Konjac rice product obtained from different formulas

4. Conclusions

Konjac rice product was produced from different formulas and screw conveyor speed. The experimental result can be concluded as following:

- The increase in the screw conveyor speed resulted in increase in product length.
- The brightness, the whiteness index and stickiness of cooked konjac rice product were decreased when RD43 rice ratio decreased.
- The highest score in all aspects was obtained from the mixing ratio of RD43 rice to konjac at 7:2.
- In term of dimension and process time, the screw conveyor speed at 6.23 rpm was recommended for production of konjac rice product.

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References

[1] Y. Hu, H. Liang, W. Xu, Y. Wang, Y. An, X. Yan, S. Ye, Q. Huang, J. Liu and B. Li. Synergistic effects of small amounts of konjac glucomannan on functional properties of egg white protein. *Food Hydrocolloids*, vol. 52, pp. 213-220. 2016.

[2] Y. Yuan, L. Wang, R. Mu, J. Gong, Y. Wang, Y. Li, J. Ma, J. Pang and C. Wu, "Effects of konjac glucomannan on the structure, properties, and drug release characteristics of agarose hydrogels," *Carbohydrate Polymers*, vol. 190, 2018, pp. 196-203.

[3] B. R. Shah, L. Bin, L. Wang, L. Shilin, Y. Li, X. Wei, J. Weiping and L. Zhenshun, "Health benefits of konjac glucomannan with special focus on diabetes," *Bioactive Carbohydrates and Dietary Fibre*, vol. 5, no. 2, 2015, pp. 179-187.

[4] R.Tester and F. Al-Ghazzewi, "Glucomannans and nutrition," *Food Hydrocolloids*, vol. 68, 2017, pp. 246-254.

[5] F. Jimenez-Colmenero, S. Cofrades, A.M. Herrero, F. Fernandez-Martin, L. Rodriguez-Salas and C. Ruiz-Capillas, "Konjac gel fat analogue for use in meat products: Comparison with pork fats," *Food Hydrocolloids*, vol. 26, 2012, pp. 63-72.

[6] S. S. Behera and R. C. Ray, "Nutritional and potential health benefits of konjac glucomannan, a promising polysaccharide of elephant foot yam, Amorphophallus konjac K. Koch: A review," *Food Reviews International*, vol. 33**,** 2017**,** pp**.** 22-43.

[7] C. Zhang, J. D. Chen and F. Q. Yang, "Konjac glucomannan, a promising polysaccharide for OCDDS," *Carbohydrate Polymers*, vol. 104, 2014, pp.175-181.

[8] P. Suklaew, C. Chusak, C.-K. Wang and S. Adisakwattana, "RD43 rice flour: the effect on starch digestibility and quality of noodles, glycemic response, short-acting satiety hormones and appetite control in humans," *Food and Function*, vol.12, 2021, pp. 7975-7985.

[9] T. Nilkamheang, "Evaluation of the Glycemic Index of RD43-Rice, and Its Products by Means of in Vitro Glucose Digestion Mimic Techniques," *Journal of Food Technology, Siam University*, (in Thai), vol. 16, 2021, pp. 59-77.

[10] Rice. THAI AGRICULTURAL STANDARD TAS 4004-2012 online available http://www.sdoae.doae.go.th/ [Assessed: June 2022]

Biographies

Lamul Wiset received her Ph.D in Food Science and Technology from University of New South Wales, Sydney, Australia in year 2007. At present, she is a lecturer in biological engineering in Mahasarakham University, Thailand. Her research interests include drying technology in particular quality of agricultural products such as rice, herbs, fruit and nut.

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