The 4th International Conference on Agriculture and Agro-Industry
ICAAI2022
Transforming Value Chains for Global Security
Mae Fah Luang University, Chiang Rai, Thailand
November 10 -11, 2022

Journal of Food Science and Agricultural Technology

International peer-reviewed scientific online journal Published online: http://rs.mfu.ac.th/ojs/index.php/jfat

Original Research Article

Physical Properties of Dried Fermented Noodle (Kanom-Jeen) Made from Organic Niang Guang Rice

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ARTICLE INFO

Article history:
Received 7 September 2022
Received in revised form 6 October 2022
Accepted 10 November 2022
Published 13 December 2022

Keywords:
Physical properties
Native rice
Niang Guang rice
Dried fermented noodles
Dried kanom jeen

ABSTRACT

Physico-chemical properties of organic Niang Guang rice flours and physical properties of fermented rice noodles were measured. The fermented rice flour showed lower values in pasting property parameters than those of the unfermented flour, especially breakdown viscosity and setback viscosity. The work to maximum load was used to explain the texture of dried noodles. The values showed a significant increase with the amount of added tapioca starch. The texture profile analysis parameters were used to explain the texture of boiled noodles. It was found that the amount of added tapioca starch resulted in a significant increase in cohesiveness and springiness index values, while decreasing hardness, chewiness, and adhesive force values. Compared to a commercial noodle, the addition of tapioca starch in the amount of 10% tended to bring the texture values of boiled noodles closer to the commercial noodle.

INTRODUCTION

Thailand is one of the major rice-producing countries in Southeast Asia. Jasmine rice is known worldwide that when cooked, it gives a floral aroma and a soft and sticky texture (Kraithong et al., 2018). However, Thailand also has many indigenous rice varieties that have been promoted to cultivation, especially in the organic system. This effort aims to ensure food security and meet the goals of the Sustainable Development Goals (SDGs).

Patitangkho et al. (2016) gathered information about Niang Kuang rice which is detailed as follows. It is one of the native rice varieties of Surin province. It is non-glutinous and red in color. Like other pigmented rice varieties, Niang Guang rice gives many health benefits. It is high in iron and contains some copper; it prevents and treats anemia. In addition, it is also suitable for diabetic patients. From the local wisdom of the ancestors, rice flour is used to make fermented noodles or Kanom-Jeen and Thai pancakes.

Fermented noodles are traditionally made of fermented flour. Non-glutinous rice is soaked and left to natural ferment for 3-4 days, milled to rice flour, left for a day for sedimentation, and drained. The flour is steamed, kneaded, pressed through a mold to form noodles, cooked in boiling water, cooled, and strained to dry (Oupathumpanont, 2009). The fermentation in the production

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ISSN: 2408-1736

process contributes to the unique flavor and texture properties of the fermented noodles (Oupathumpanont, 2009; Keatkrai and Jirapakkul, 2010; Shompoosang et al., 2019). A soft but elastic or chewy mouthfeel is the desired texture (Keatkrai and Jirapakkul, 2010; Shompoosang et al., 2019). During fermentation, not only lactic acid bacteria but also proteolytic bacteria play important roles in producing that texture (Keatkrai and Jirapakkul, 2010). A decrease in rice protein content was found. Protein digestion liberates starch granules, causing the starch to gelatinize more readily during heating. Protein digestion was identified that it was associated with the development of fermented noodles' texture characteristics (Shompoosang et al., 2019). Compared to non-fermented noodles, fermented noodles gave higher tensile force, young's moduli (Oupathumpanont, 2009), hardness, and elongation (Satmalee et al., 2017).

With the desire to develop a product from Niang Guang rice by upgrading from the local wisdom to an alternative food choice for consumers in modern lifestyles, this research aimed to study the physical properties of dried and boiled fermented noodles made of Niang Guang rice flour. Hopefully, this information would be helpful for further development of commercial dried fermented noodles from organic Niang Guang rice.

MATERIALS AND METHODS

Materials

Organic Niang Guang rice was purchased from the Organic Rice Cooperative, Surin Province, Thailand. Tapioca starch was purchased from Bangkok Inter Food Co., Ltd. Commercial dried (Kanom-Jeen) noodles were purchased from a local department store. It was produced by a community enterprise in Loei Province, Thailand. Its main ingredients were corn starch and 10% of tapioca starch.

Rice flour preparations

Flour from Niang Guang rice was prepared in 2 samples, unfermented rice flour and fermented rice flour. Unfermented rice flour was prepared by soaking Niang Guang rice grains in water (1:1 by weight) for 2 hr, then milled after draining and tray dried at 50ºC for 2 hr. For fermented rice flour, Niang Guang rice grains were soaked overnight in water (1:1 by weight). The soaked grains were transferred into a shallow bamboo basket to remove an excess amount of water, then covered with a plastic sheet. The grains were naturally fermented for 3 days and washed twice a day during the fermentation. Then, the fermented grains were milled and the fermented rice flour was stored in a net cloth and precipitated overnight. After removing excess water, a sample of the fermented rice flour was taken to a tray dryer and was dried at 50ºC for 2 hr.

Dried fermented rice noodle preparations

To form fermented rice noodles, the wet fermented flour, after removing the excess water, was mixed with tapioca starch at 0, 5, or 10% by weight, steamed at 95-98ºC for 15 min and kneaded for 20 or 30 min to form a rice dough. Then, the dough was squeezed through a stainless-steel mold to make 12-inch-long fermented noodles. The noodles were line-dried overnight at room temperature.

Boiled or reconstituted noodles preparation

To reconstitute, 50 g of dried fermented rice noodles or dried commercial noodles were boiled in 1,500 g of water for 15 min. The boiled noodles were put into ice water to cool down to room temperature. Then, they were drained in a strainer and stored in a plastic Ziplock bag.

Physico-chemical property measurements of rice flours

Six analyses were performed for both unfermented and fermented rice flours. The proximate composition such as moisture, carbohydrate, ash, crude protein, and crude fat contents was determined by the method of AOAC (AOAC, 2012). The water activity was determined using a water activity meter (Aqualab CX3TE, METER Group, Inc., USA). The amylose content was determined by the method of ISO 6647-2:2007 (ISO, 2007). Sieve analysis with mesh numbers 16, 25, 50, and 170 was used to access the particle size distribution of the flours. The pasting properties were determined using a rapid visco analyser (RVA TecMaster, PerkinElmer Inc., USA). And, the color parameters L*, a*, and b* were determined by using a colorimeter (Miniscan EZ, HunterLab, USA).

Physical property measurements of fermented rice noodles

The moisture content and color attributes of the dried fermented rice noodles were determined. The texture characteristics of both dried fermented noodles and commercial noodles were determined with a 3-point bending technique using a material testing machine (Lloyd LR5K, Lloyd Instruments Ltd., England).

For boiled noodles, the texture characteristics of both fermented rice noodles and commercial noodles were determined using a texture profile analysis technique. Fifty grams of noodles were stored in an acrylic cylinder 60 mm high and they were pressed twice with a flat 4 cm-diameter probe. The pressing distance was 30 mm. The color attributes of the fermented rice noodles were also determined.

Statistical analysis

The physical properties data of dried and boiled fermented noodles were compared with that of dried and boiled commercial noodles. ANOVA and Tukey comparison testing at a 5% significant level was used (SPSS, version 28.0.1.1 (15), SPSS Inc., USA).

RESULTS AND DISCUSSION

Physico-chemical properties of rice flours

The physico-chemical properties of the flours are shown in Table 1. Since the rice grains contained red pigment, the flours were a slight reddish-brown in color. This appearance could be confirmed by the positive values of color parameters, a* and b*. The pigment could associate with anthocyanin content in the grains (Kraithong et al., 2010).

The particle sizes of both flours were mostly distributed in the range of 90-300 μm followed by < 90 μm and 300-710 μm, respectively. The moisture contents and water activity values of both flours fell in the range of dry food products that would be safe for ambient storage.

The flours contained high carbohydrate and contained around 25% (dry basis) amylose content. According to the presence of amylose concentration, Niang Guang rice can be categorized as high amylose rice based on the criteria of Tao et al. (2019). Tao et al. also confirmed that rice varieties containing high amylose and in a combination with specific amylopectin characteristics tended to have higher hardness and lower eating preference. The amylose content is also one of the factors that indicate the likelihood of rice having a low glycemic index (Chang et al., 2014), which supports the claim that Niang Guang is suitable for diabetics. Because it is less palatable, it should be developed into processed food. Rice noodles are good options; the desired texture and properties of rice noodles are made from flour containing more than 22% amylose concentration (Ahmed et al., 2016).

The significant differences in physico-chemical properties of the flours could be due to the rice fermentation process. During the fermentation, proteolytic bacteria digest protein and which causes starch granule (carbohydrate) liberation (Shompoosang et al., 2019). Therefore, a slightly higher content of carbohydrates was found in the fermented flour. The color parameters, a* and b* values, of both flours were also significantly different. Satmalee et al. (2013) found that the color parameters, L*, a*, b*, of fermented immature rice flours were significantly different from those of the unfermented rice flour, and the differences in color parameters were dependent on fermentation time. They surmised that detaching the aleurone layer of the rice grains during the fermentation process resulted in a change in flour's color. Shompoosang et al. (2019) also found differences in brightness and whiteness values of fermented noodles with different proteolytic culture strains.

The pasting property parameters of both control and fermented rice flours are shown in Table 2. All parameters of both flours were significantly different at $p < 0.05$. All viscosity values were higher in the case of fermented flour. This phenomenon was similar was also observed in rice flours fermented by lactic acid bacteria (Yang and Tao, 2008). The breakdown and setback viscosity can be used to estimate the texture of cooked flour and noodles. Breakdown viscosity refers to the susceptibility of cooked flour to disintegrate; setback viscosity refers to the degree of hardening of cooked flour during cooling (retrogradation). A significant reduction in both viscosity values indicated strong structure of the rice flour that reduced paste disintegration and lower the degree of rice flour retrogradation (Yang and Tao, 2008).

Physical properties analyses of fermented rice noodles

As seen in Figure 1, overall, boiled noodles had lower color parameter values that those of dried noodles. This was due to cooking loss during boiling causing loss of pigments.

In Table 3, the moisture contents of dried noodles were in the range of 11.06-11.13% wet basis, which was suitable for dry food products. The work to maximum load was used to represent the hardness of the dried noodles, the higher value of the work, the higher degree of the hardness. The work increased with the amount of added tapioca starch. But the kneading time did not show any significant effect. If using the commercial noodles as a benchmark, regardless of kneading time, adding tapioca starch would improve the texture of the dried noodles.

Table 1. Physico-chemical properties of Niang Guang rice flours

Flour	Proximate composition and amylose content (%)				
	Ash	Fat	Protein	Carbohydrate	Amylose
Unfermented	$1.36 \pm 0.01^{b*}$	3.16 ± 0.02	6.54 ± 0.06	80.88 ± 0.03^{a}	25.19 ± 0.16
Fermented	1.06 ± 0.07^{a}	3.19 ± 0.05	6.63 ± 0.09	81.33 ± 0.04^{b}	24.59 ± 0.22
Flour	Moisture content (%)	Water activity	Color parameter		
			L*	a*	b*
Unfermented	8.00 ± 0.09^{b}	0.33 ± 0.01^{b}	76.08 ± 0.49	5.95 ± 0.09^{b}	9.24 ± 0.08^{a}
Fermented	7.05 ± 0.11^{a}	0.26 ± 0.00^{a}	77.30 ± 0.62	5.55 ± 0.11^{a}	9.63 ± 0.17^{b}
Flour	Particle distribution (%)				
	> 1,180 μm	710-1,180 μm	300-710 μm	90-300 μm	< 90 μm
Unfermented	0.16	1.27	11.30	44.21	35.92
Fermented	0.54	4.39	12.31	50.54	31.45

*Means ± SD in the same column identified by different superscripts are significantly different ($p < 0.05$)

Table 2. Pasting properties of Niang Guang rice flours

Flour	Peak viscosity (cP)	Trough viscosity (cP)	Breakdown (cP)	Final viscosity (cP)	Setback (cP)
Unfermented	$2,805.67 \pm 20.82^{b}$	$1,782.00 \pm 6.56^{b}$	1023.67 ± 14.36^{b}	$4,145.33 \pm 62.07^{b}$	$2,363.33 \pm 21.93^{b}$
Fermented	$2,421.00 \pm 8.54^{a}$	$1,637.33 \pm 18.01^{a}$	783.67 ± 13.01^{a}	$2,690.33 \pm 64.36^{a}$	$1,053.00 \pm 77.95^{a}$

*Means ± SD in the same column identified by different superscripts are significantly different ($p < 0.05$)

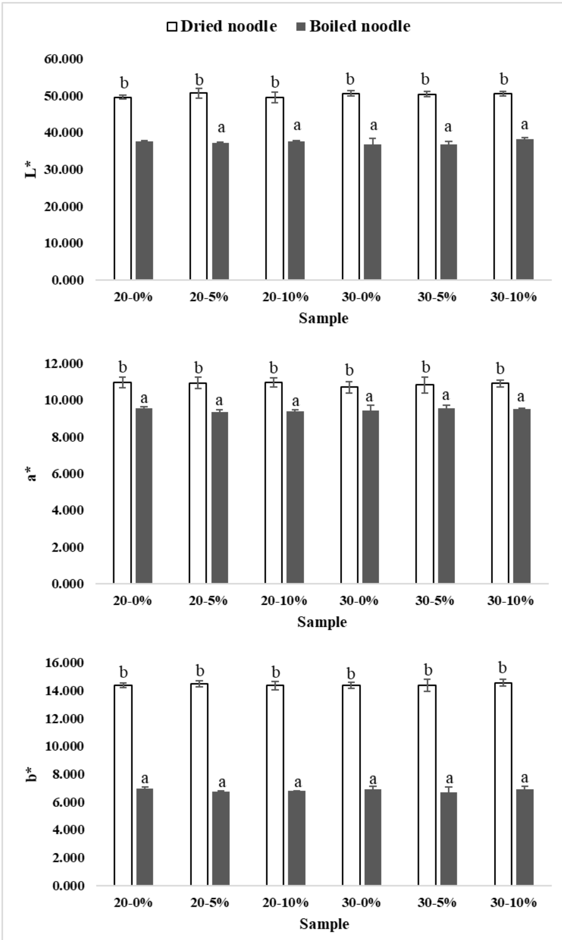

Figure 1. Color parameters of fermented noodles (Means ± SD identified by different lowercase letters are significantly different at $p < 0.05$)

The texture parameters of the boiled noodles are shown in Table 4. Similar to the dried noodles, the tapioca starch content had a significant effect ($p < 0.05$) while the kneading time had no significant effect on the texture values. The hardness, chewiness, and adhesive force values decreased with the amount of added tapioca starch, while the cohesiveness and springiness index showed the opposite effect. If the commercial noodles were a benchmark, regardless of kneading time, adding a 10% or higher amount of tapioca starch may elevate the texture value close to the commercial noodle. From the result, it can be suggested that tapioca starch plays an important role in the texture of fermented noodles. Tapioca starch had high swelling power, solubility and gel strength. Blending it with rice flour or rice starch in an appropriate ratio would result in effective synergistic effects. The blending starch showed improvements in swelling power, solubility, gel strength and elastic property (Sun and Yoo, 2015). Liu et al. (2017) found that 5-10% of tapioca starch in a combination with broken rice flour and full rice flour could give good texture quality of composite rice noodle.

Table 3. Physical properties of dried fermented rice noodles

Sample	Moisture content (% wet basis)	Work at maximum load (kgf.mm)
20-0%*	11.19 ± 0.04	0.087 ± 0.011^{ab}**
20-5%	11.55 ± 0.23	0.069 ± 0.006^{a}
20-10%	11.13 ±0.05	0.109 ± 0.015^{bc}
30-0%	11.68 ± 0.09	0.071 ± 0.000^{a}
30-5%	11.61 ± 0.01	0.088 ± 0.004^{abc}
30-10%	11.93 ± 0.16	0.109 ± 0.006^{c}
Commercial	11.74 ± 0.19	0.069 ± 0.006^{a}

*20-0%: 20 is kneading time; 0% is tapioca addition**Means ± SD in the same column identified by different superscripts are significantly different ($p < 0.05$

The commercial noodles contain mainly corn starch and tapioca starch. This suggests that corn starch or a combination of corn starch and tapioca starch could give contributions to rice noodle texture. Surojanametakul et al. (2002) found that the texture characteristics of rice noodles are dependent on the amount and type of added starch. Cooking yield significantly increased with an increase in casava content. The cassava starch may contribute to a slight increase in water absorption of the noodle. In general, cassava starch gave noodles a transparent, soft, and sticky texture. An increase in adding the amount of cassava starch increased the extensibility and stickiness of the rice noodle; this may strengthen the noodles and enhance the cohesiveness and springiness of the noodles. However, from sensory testing, adding the amount of cassava starch to 20% caused undesirable texture and acceptability. On the other hand, adding 20% of corn starch resulted in the highest scores in both texture and acceptability.

Pato et al. (2016) found that the ratio between corn flour and tapioca flour had a prominent effect on instant noodle quality. Increasing the ratio to 45:55, the intactness of the instant noodle significantly increased. Tapioca flour contains high starch, it tended to lower the water content of the noodle and consequently yielded extreme gelatinization and swelling during the heating process.

The combination of corn and tapioca starches seemed to be an interesting choice for improving the desirable dried fermented noodle texture. The effect and adding amount of the combination should be further studied.

Table 4. Texture parameters of boiled noodles

Sample	Hardness (N)	Cohesiveness	Springiness index	Chewiness (N.m)	Adhesive force (N)
20-0%*	31.487 ± 4.517^{cd}	0.263 ± 0.023^{a}	0.408 ± 0.014^{a}	0.067 ± 0.016^{b}	2.340 ± 0.389^{c}
20-5%	29.136 ± 2.601^{cd}	0.309 ± 0.017^{bc}	0.415 ± 0.041^{a}	0.062 ± 0.007^{b}	2.290 ± 0.123^{c}
20-10%	24.251 ± 3.800^{bc}	0.318 ± 0.011^{c}	0.479 ± 0.012^{bc}	0.043 ± 0.007^{ab}	2.220 ± 0.092^{bc}
30-0%	36.279 ± 3.180^{d}	0.275 ± 0.010^{ab}	0.437 ± 0.014^{ab}	0.058 ± 0.005^{ab}	2.522 ± 0.412^{c}
30-5%	26.004 ± 4.281^{bc}	0.327 ± 0.005^{c}	0.501 ± 0.012^{c}	0.053 ± 0.014^{ab}	2.230 ± 0.171^{bc}
30-10%	17.394 ± 0.528^{ab}	0.340 ± 0.006^{c}	0.524 ± 0.021^{c}	0.048 ± 0.004^{ab}	1.578 ± 0.173^{b}
Commercial	10.560 ± 0.569^{a}	0.456 ± 0.018^{d}	0.646 ± 0.018^{d}	0.034 ± 0.004^{a}	0.236 ± 0.010^{a}

*20-0%: 20 is kneading time; 0% is tapioca addition

**Means ± SD in the same column identified by different superscripts are significantly different ($p < 0.05$)

CONCLUSIONS

Niang Guang rice flour had a high amylose content and would appear to be suitable for processing into rice noodles. Bacterial activity during rice flour fermentation resulted decreasing in pasting parameters, which could result in less disintegration and retrogradation of fermented noodle. Tapioca starch content had a significant effect on the texture of dried and boiled fermented noodles. Considering boiled noodles, the consequence of adding tapioca starch at 10% would yield a texture close to the commercial one, the commercial noodles containing corn and tapioca starches. Thus, the effect of a combination of these starches mixed in the fermented rice flour should be further studied. This would benefit the further development of commercial dried fermented noodles from organic Niang Guang rice.

ACKNOWLEDGEMENTS

This research was supported by a grant from the Faculty of Engineering at Kamphaeng Saen, Kasetsart University, Thailand.

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