Preparation of Rice Vermicelli by Direct Extrusion

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Abstract

The effects of process factors (screw speed, feeder screw speed, and barrel temperature, drying temperature) on extruded rice vermicelli properties by using a single screw extruder were examined. The results of the optimum conditions for the extrusion process were: screw speed 30 rounds per minute; feeder speed, 50 rounds per minute; the temperature of first zone: second zone: third zone as 90^{O}C: 100^{O}C: 100^{O}C. Drying time and temperature significantly affected the product quality. The product dried at room temperature for 24 hours before packing gave good appearance with final moisture content less than 12%. When cross-linked modified starch type, MYK-500T 4%, and emulsifier, monoglyceride Monomul 90-35P 1.00%, were added to the rice flour, the product showed cooking weight at 315.68%, cooking loss 11.10% and final moisture content 8.72%. The hardness of the product was 1,230.25 g and tensile strength 9.50 g. The acceptance of the extruded rice vermicelli was not significantly different from commercial rice vermicelli obtained by traditional process.

Keywords: Rice noodle, cooking weight, cooking loss, degree of gelatinization, extrusion, waste water disposal

1. Introduction

Rice noodle (vermicelli) is a popular type of noodle served as Oriental dishes both in Eastern and Western countries. The traditional process of rice vermicelli involves in extruding partially gelatinized rice paste from freshly prepared milled rice into vermicelli-sized noodles. Dry rice flour could be used to prepare extruded rice vermicelli instead of using wet milled rice due to the reduction of waste water disposal. This process, in turn, could speed up the rice vermicelli production, easy to handle and sanitize. Extrusion cooking is a continuous process with high production capacity, versatility, and low cost per product unit. [1] The rice noodles are judged by their uniformity, cooking and eating quality. Plasticity of dried noodles, whiteness, low cooking loss, retention of shape, and non-sticking when cooked are desirable properties of extruded rice noodles. [2, 3, 4] Dry rice flour may be used to prepare rice noodles by extrusion cooking. [5, 6] Rice flour was pre-moistened to 35.0, 37.5 and 40.0% moisture before extruded through a single screw extruder and dipped into hot water (95^{O}C) for 15 second. [6] This paper discusses the effect of extrusion factors on rice noodle, vermicelli, properties and to improve the product quality by using modified starch and emulsifier.

2. Materials and Methods

2.1 Rice flour

Commercial rice (*Oryza sativa* L.) flour and modified starch (high cross-link), MYK-500T, was kindly obtained from Bangkok Inter Food Co., Ltd. Monomuls 90-35P, the fatty acid monoglyceride emulsifier based on palm oil was a gift from Cognis Thai, Ltd., Thailand.

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2.2 Extrusion processing

The preparation of rice paste at 30% (wet basis) in Kenwood mixer was performed by adding warm water at 40^{O}C to rice flour. The mixture was mixed slowly at low speed (level 1) for 25 min and incubated at ambient temperature for 6 hrs. The pre-moistened flour was uniformly fed to a single screw extruder (Brabender-19/20 DN) with the following specifications: barrel length, 382 mm; barrel diameter, 19.1 mm; 3 zone barrel; die diameter, 0.6 mm and 4:1 compression ratio screw. The effect of screw speed at 20, 30, 40 rpm and feeder screw speed at 20, 30, 40, 50 and 60 rpm on the noodle properties was studied. The barrel temperature of zone 1: zone 2: zone 3 was controlled at 70:100:90^{O}C. The extruded noodles were air-dried at ambient temperature for 24 hrs and kept in sealed polyethylene bags before used.

The effect of barrel temperature in three zones was studied by factorial design with 3x2x2 level. Modified starch, MYK-500T at 1, 2, 3, 4, 5, 6% and emulsifier, Monomul 90-35P at 0.2,0.4, 0.6, 0.8 and 1.0% was added to rice flour to improve the stickiness of rice vermicelli. The extruded rice vermicelli was compared with three main commercial rice vermicellis in terms of physical and cooking quality. The effect of drying temperature on rice vermicelli was studied at 40, 50, 60^{O}C for 5, 10,15, 20, 25, and 30 min.

2.3 Analytical Methods

Rice flour was analyzed for moisture, ash, protein, and lipid according to standard AACC methods [7], and amylose was determined by Juliano [8]. Degree of gelatinization was determined by differential alkaline solubility. [9] Cooked noodle hardness was measured by texture analyzer TA-XT2.

Cooking time, cooking weight, and cooking loss was determined following AACC [10]. Five grams (5 cm long) of rice vermicelli were placed in 300 ml of boiling water in a 500 ml beaker. Noodle strands were removed at regular intervals and pressed between two glass plates. Time required for the opague part in the strand to be gelatinized was considered as cooking time. Cooking weight (% dry basis), as a measure of the degree of noodle hydration of a 25 g dry noodles cooked in 300 ml boiling water at optimal cooking time, was recorded. Cooking loss (% dry basis), weight of total solids loss during cooking, was measured by evaporating the noodles cooking water to dryness in a 100±1^{O}C oven for 20 hr. All analysis methods were done in triplicate.

2.4 Sensory evaluation

The preference test was carried out using 9 point hedonic scale with 15 panelists. Cooking quality was determined by visual determination. Three categories of cooking quality were retention of shape, non-sticking, tensile. The scores were ranked from one to four, indicating as the unacceptability to acceptability.

2.5 Statistical analysis

All experiments in extrusion processing were carried out in replicate. The data was analyzed using analysis of variance (ANOVA) and Duncan's multiple range test. [11]

3. Results and Discussion

3.1 Effect of Extrusion Variables

The moisture, protein, lipid, ash and amylose content of the dry rice flours were (wet basis) 10.70, 7.50, 0.63, 0.24, and 27.83% respectively. From visual judging, the results of cooked rice vermicelli showed unacceptability in all categories when the sample used screw speed at 20 rpm and at any speed of feeder screw. The screw speed at either 30 or 40 rpm showed little impact on score ranking. The highest acceptable score was presented in the sample used screw speed and feeder speed at 30 and 50 rpm respectively.

The increase of barrel temperature of both zone 1 and zone 2 tended to increase % cooking weight and adversely reduce % cooking loss (Table 1). Surface gelatinization of traditional extruded noodles has been shown to be critical for hot-water stability of the noodles. [12] The extruded rice vermicelli at 90:100:100 showed cooking loss at 7.11% which is within the accepted range for commercial noodle (less than 12.5%). [13] No significant ($P<0.05$) changes of noodle size. Cooking time of all samples obtained was 1.5 min. Comparing to this, Khandker et al. [6] reported that cooking time and cooking loss of rice vermicelli extruded at 35% moisture content at 55^{O}C barrel temperature were 3 min and 0.18% respectively. However, the authors describe that the extruded noodles had to be dipped in hot water (95^{O}C) for 15 s, cooled in cold water and air-dried at ambient temperature. Actual cooking loss could be higher due to the loss during dipping and cooling process.

Table 1 Effect of barrel zone temperature on physical and cooking properties of extruded rice vermicelli*

Barrel temp (zone 1: zone2: zone 3)	Dried noodle size (mm)^{ns}	Cooking weight (%)	Cooking loss (%)
70: 100: 100	0.66	246.22^{a}	14.28^{d}
70: 110: 100	0.74	262.05^{b}	10.33^{b}
80: 100: 100	0.70	287.90^{c}	12.10^{c}
80: 110: 100	0.73	306.37^{d}	9.79^{b}
90: 100: 100	0.70	336.28^{e}	7.11^{a}
90: 110: 100	0.71	320.03^{de}	7.28^{a}

ns: Not significantly different at the level 5%

* Means in the same column followed by the same letter are not significantly different at the level 5% level by Duncan's multiple range test

Table 2 Effect of modified starch on cooking quality of extruded rice vermicelli

Modified starch (%)	Cooking weight (%)	Cooking loss (%)
0	336.28^{c}	7.11^{a}
2	289.11^{b}	10.68^{b}
4	284.90^{b}	10.12^{b}
6	263.39^{a}	9.38^{b}

Table 3 Effect of emulsifier on cooking quality of extruded rice vermicelli

Emulsifier (%)	Cooking time (min)	Cooking weight (%)	Cooking loss (%)
0	1.50^{b}	336.28^{c}	7.11^{a}
0.5	1.50^{b}	291.35^{b}	8.12^{a}
1.0	2.00^{c}	276.46^{a}	12.14^{b}

3.2 Improvement of Stickiness by Using Modified Starch and Emulsifier

The dried extruded rice vermicelli had white color, good retention of shape after cooking but sticking together after standing for a while. Native starches are generally not resistant to high temperatures and high-shear processing conditions involved in the extrusion process. The breakdown of the starch granules and formation of dextrins and short chain polymers during processing results in a sticky dough. [14] Cross-linked starch has more resistant to shear degradation was used to provide noodle with better stability. The rice vermicelli extruded from dry rice flour (30% moisture content) mixed with 4 or 6% cross-linked modified starch, MYK-500T, resulted in non-sticking product. However, excessive cross-linking may lower the swelling capacity of the starch as indicated by the decrease of cooking weight and increase of cooking loss (Table 2). Light to moderately cross-linked should be considered instead to improve the product cooking quality without reduction of cooking weight.

The use of food emulsifier, monoglyceride Monomuls 90-35P, could also improve the stickiness of the extruded rice vermicelli. The ability of monoglycerides to form water-insoluble complexes with amylose is thought to result in this reduced stickiness. [15] Amylose complexation with monoglycerides can shift starch gelatinization temperature and viscosity profiles of the resulting paste leaded to the decrease of cooking weight and increase of cooking loss (Table 3).

3.3 Comparison between Extruded Rice Vermicelli and Commercial Rice Vermicelli

Figure 1 shows rice vermicelli obtained from the extrusion with rice flour mixed with modified starch, MYK-500T and emulsifier at 0.2%, 0.4%, 0.6%, 0.8% and 1.00% respectively. The texture of cooked-rice vermicelli extruded from rice flour mixed with 4% MYK-500T and 1% Monomuls 90-35P was compared with 3 commercial products obtained from traditional process (Table 4). The extruded product revealed softer texture but no significant difference in tensile strength. However, the preference test of all 3 products and the extruded vermicelli were not significantly different in all attributes tested (Table 5). The product showed cooking weight and cooking loss at 315.68% and 11.10% respectively. Moreover, the extruded rice vermicelli could be cooked (with or) without steeping in water before the cooking as needed for the rice vermicelli obtained from traditional process. This leads to time saving and user-convenience.

3.4 Drying Time

The low moisture content of extruded rice vermicelli (about 14-15%) resulted to short drying time and the saving in space and equipment cost (Table 6).

4. Conclusion

Dry rice flour at 30% moisture content could be used to prepare rice vermicelli by direct extrusion process. The product indicated acceptable cooking quality with slight stickiness after cooking. The use of cross-linked modified starch and monoglyceride could improve the stickiness and the product obtained did not show significant difference in term of preference test with commercial products obtained from traditional process. The extruded rice vermicelli showed cooking time at 1.5 min and could be cooked directly without steeping process before cooking. The time needed to dry the extruded rice vermicelli was less than 10 min at 40-60^{O}C since the extruded product already indicated low moisture content (14-15%).

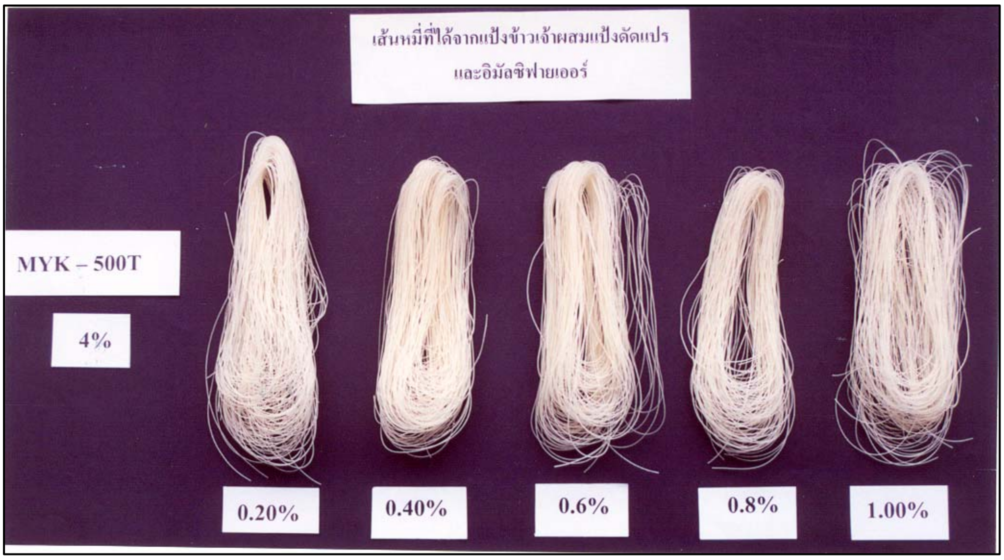

Figure 1 Rice vermicelli obtained from the extrusion with rice flour mixed with modified starch MYK-500T and emulsifier at 0.2%, 0.4%, 0.6%, 0.8% and 1.00% respectively.

Table 4 Textural properties of cooked-extruded rice vermicelli compared to commercial products produced by traditional process

Sample	Hardness (g)	Tensile strength (g)
Brand 1	1,580.51[b]	10.57[b]
Brand 2	2,007.83[c]	9.33[a]
Brand 3	1,816.34[c]	9.87[ab]
Extruded vermicelli	1,230.25[a]	9.50[a]

* Means in the same column followed by the same letter are not significantly different at the level 5% level by Duncan's multiple range test

Table 5 Sensory evaluation of cooked-extruded vermicelli compared to commercial products by 9 point hedonic scale

Sample	Color[ns]	Non-sticking[ns]	Well cooked[ns]	Texture[ns]	Overall acceptance[ns]
Brand 1	7.50	7.00	7.00	6.77	7.03
Brand 2	7.27	6.43	7.17	6.90	7.03
Brand 3	7.13	6.30	7.10	6.67	6.50
Extruded vermicelli	7.40	6.93	7.27	6.87	7.00

ns: Means in the same column are not significantly different at the level 5%

Table 6 Effect of drying temperature on extruded rice vermicelli moisture content and appearance

Temp (°C)	Time (min)	Moisture content (%)	Noodle appearance*
40	10	12.29	No air bubble inside
	20	11.88	Very few air bubble inside
	30	11.50	Very few air bubble inside
50	10	11.47	No air bubble inside
	20	11.28	Very few air bubble inside
	30	10.77	Very few air bubble inside
60	10	11.38	No air bubble inside
	20	10.44	No air bubble inside
	30	10.02	Very few air bubble inside

* All samples showed smooth surface and white color

5. Acknowlegement

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