2012 International Conference on Nutrition and Food Sciences
IPCBEE vol. 39 (2012) © (2012) IACSIT Press, Singapore

Physicochemical and Thermal Properties of Non-Waxy Rice Flour as Affected by Waxy Rice Flour and Its Influence on Textural and Cooking Properties of Rice Spaghetti

Pakkawat Detchewa, Masubon Thongngam, and Onanong Naivikul +

Department of Food Science and Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, 10900, Thailand

Abstract. In the present study, a dry milling method was applied to prepare rice flour from 2 rice varieties, Chai Nat 1 and Rice Division 6 (RD6), which were used to make rice spaghetti. The spaghetti samples were made from flours obtained by dry-milled Chai Nat 1 (DMCNT1; non waxy) rice flour and blending of dry-milled RD6 (DMRD6; waxy) to dry-milled Chai Nat 1 (DMCNT1; non waxy) rice flour at three different ratios (5:95, 10:90, and 15:85). Amylose content, physicochemical, and thermal properties of flours were determined. The cooking properties of rice spaghetti samples were evaluated through textural properties, cooking qualities and microstructure. The amylose content of DMRD6 and DMCNT1 were 4.42 and 33.36 % dry basis, respectively. The blending ratios of DMRD6 to DMCNT1 from 5 to 15: 95 to 85 significantly decreased the amylose content of flours. The pasting and thermal properties of rice flours determined by using a rapid-visco analyser (RVA) and differential scanning calorimeter (DSC) indicated that blending of DMRD6 to DMCNT1 significantly decrease the pasting temperature, setback value and final viscosity. The retrogradation enthalpy of the blending of DMRD6 to DMCNT1 samples were also decreased with the increasing of DMRD6 rice flour level. The cooked rice spaghetti made from the blended flour of DMRD6 and DMCT1 at the ratio of 10:90 gave the highest tensile strength and the lowest cooking loss. From the study by a stereomicroscope, the cooked rice spaghetti made from DMCT1 had a uneven surface, in contrast to the surface of cooked rice spaghetti from blended flour (DMRD6 to DMCNT1; 10:90), which had smooth surface. Therefore, the blending of waxy rice flour to non waxy rice flour could improve rice spaghetti quality by reducing retrogradation value and improving the surface appearance of the rice spaghetti made from the optimum ratio of 10:90 (DMRD6:DMCNT1) rice flour.

Keywords: Rice flour, Waxy rice flour, Gluten free, Rice spaghetti

1. Introduction

In recent years, there has been increased in demand of gluten free products that are suitable for people with celiac disease, which is gluten sensitivity, an inflammatory disorder of upper small intestine. Gluten protein is a component in wheat, rye, barley and possibly oat products [1]. Rice protein is considered as hypoallergenic protein (no gluten) [2]. Rice flour made from wet-milled flour is generally ingredient for using in many food products such as sauce, rice noodle, and gluten free products. However, the wet-milling process requires large amounts of water and energy. Thus, the dry-milling is an interesting process. The study by Suksomboon and Naivikul [3] found that rice noodle from high amylose (dry-milled RD 7 rice flour, 26.37 % amylose and dry-milled Leuang 11 rice flour, 32.21 % amylose) provided the better cooking and textural properties than low amylose (dry-milled Phatum Thani 1 rice flour, 13.97% amylose). The amylose content in rice flour plays an important role on the textural properties of rice noodle [3]. In addition, the amylose content in rice flour related to the gelatinization temperature and degree of retrogradation. The high amylose content in rice flour had higher gelatinization temperature and higher retrogradation than low

+ Corresponding author. Tel.: + 66(0)2-562-5023; fax: +66(0)2-562-5201.
E-mail address: fagionn@ku.ac.th.

amylose content [4]. The objectives of this study were to investigate the effect of blending dry-milled waxy rice flour to dry-milled rice flour on amylose contents, pasting properties, and thermal properties, and to determine optimum ratio between of the dry-milled waxy rice flour and rice flour for making rice spaghetti.

2. Materials and Methods

2.1. Preparation of Rice Flours

Two rice (*Oryza sativa*, L.) varieties used in this study were RD6 (waxy rice) and Chai Nat 1, (high amylose and non waxy rice) obtained from Bureau of Rice Research and Development, Thailand. Paddies were polished by husker and then dry milled. The rice flour samples were prepared by grinding and passing through a 100 mesh sieve [5]. Moisture content of DMCNT1 and DMRD6 was 11.45 and 10.82 %, respectively. After that DMCNT1 was mixed with DMRD6; at three different ratios including; 5:95, 10:90 and 15:85 (DMRD6:DMCNT1) based on dry basis.

2.2. Amylose Contain in Rice Flours

The DMCNT1, DMRD6 and blended flours were determined the apparent amylose content (%) by following the method of Juliano *et al.* [6].

2.3. Pasting Properties of Flours

The pasting property of rice flours were determined by using the rapid visco-analyser (RVA 4, Newport Scientific, Australia). In this assay, 3.0g (dry basis) of flour was dispersed in 25 mL of distilled water. The heating and cooling cycles were programmed according to AACC [7] 76-20 method. Pasting temperature, peak time, trough, breakdown, setback and final viscosity, were calculated by using the Thermocline software.

2.4. Gelatinization and Retrogradation Properties of Flours

Gelatinization properties of rice flours were analysed by using differential scanning calorimeter (DSC) (DSC 1, Mettler Toledo, Switzerland). The rice flour (4 mg, dry basis) was weighed into an aluminum DSC pan and added with 8 mg of deionized water to reach a water-flour ratio of 2:1. Thermal scanning was from 30 to 95 ºC at heating rate of 10°C/min using an empty pan as reference [3]. The onset temperature (To), peak temperature (Tp), conclusion temperature (Tc), and gelatinization enthalpy (ΔH_G) were recorded. The gelatinized flour was stored at 4ºC for 7 days to allow them to retrograde. The retrograded flour was rescanned by the same condition as gelatinization study and the retrogradation enthalpy (ΔH_R) were recorded [8].

2.5. Preparation of Rice Spaghetti

Rice spaghetti samples were prepared by mixing both rice flour samples with water to obtain 40-45% moisture content of dough. The rice dough was steamed for 30 min (steam cooker, Nesco,Thailand), after that rice dough was kneaded for 30 min. Then, rice dough was extruded by using spaghetti die by lab-scale extruder (Buo-143536, Nuc Electrics, Korea). Finally, the rice spaghetti was dried at 40^{o}C in tray dryer until reaching 10% moisture content.

2.6. Evaluation of Cooked Rice Spaghetti

Optimum cooking time and cooking loss were determined following AACC [7]. The rice spaghetti products were determined the textural characteristics by using a texture analyser (TA-XT Plus, Stable Micro System, Godalming, UK). Firmness of rice spaghetti products were measured by using a 1 mm flat Perspex knife blade (A/LKB-F)[7]. Stickiness was determined by using P35, 35 mm dimension cylinder probe following Stable Micro Systems. Each test was performed on 5 strands of rice spaghetti for stickiness and firmness. Elasticity or tensile strength was measured by using the A/SPR-Spaghetti/Noodle Rig following Stable Micro Systems. Appearances (smoothness and uniformity) of dried and cooked rice spaghetti products were tested by observation and using stereomicroscope (x 10) (Leica, S8APO, Germany).

2.7. Statistical Analysis

The mean values, standard deviations, and analyses of variance (ANOVA) were calculated using SPSS software, version 15. Means comparisons were performed using Duncan's multiple range test (DMRT). Significance of difference was defined at $p < 0.05$.

3. Results and Discussion

3.1. Amylose Contents

The amylose contents of DMCNT1 and DMRD6 rice flours were 33.65 and 4.42 %, respectively (Fig. 1). The amylose contents of blended flours, DMRD6:DMCNT1 (5:95, 10:90, and 15:85), were 31.10, 29.82 and 26.97 %, respectively.

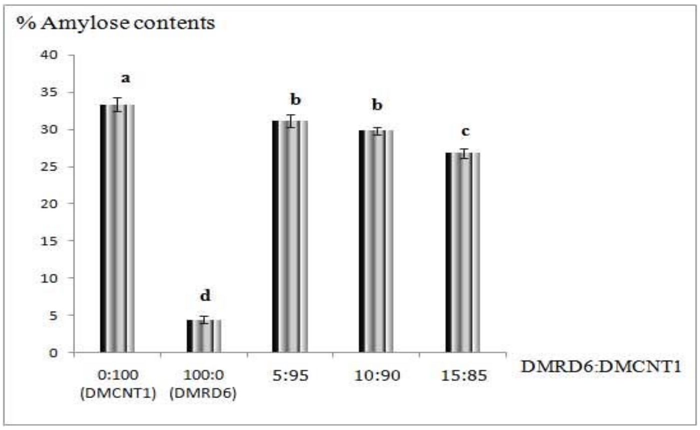

Fig. 1: Amylose content (%) of DMCNT1, DMRD6, and blended flours (DMRD6 and DMCNT1 at 5:95,10:90, 15:85)

3.2. Pasting Properties

Pasting properties of flours are shown in Table 1. The pasting properties of DMCNT1 and DMRD6 were significantly different ($p<0.05$). The pasting temperatures of DMCNT1 and DMRD6 were 83.63 and 70.70°C, respectively, whilst the blended flours were ranged from 81.83 to 82.58°C, which were significantly different ($p<0.05$) from DMCNT1 and DMRD6. The setback of DMCNT1 had the highest value (253.13 RVU), while DMRD6 had the lowest setback (56.80 RVU). The setback value of blended flours (DMRD6 to DMCNT1) at 5:95 (233.44 RVU) and 10:90 (226.22 RVU) were not significantly different ($p>0.05$), but there were significantly different ($p<0.05$) from DMCNT1. The setback of blended flour was decreased with the increasing levels of the DMRD6, because it might be the amylose contents were decreased.

Table 1 Pasting properties of DMCNT1, DMRD6, and blended flours (DMRD6 and DMCNT1 at the ratios 5:95, 10:90, 15:85)

DMRD6: DMCNT1 (%replacement)	Pasting temperature (°C)	Peak time (min)	RVA viscosity (RVU)				
			Peak	Tough	Breakdown	Setback	Final
0:100 (DMCNT1)	83.63 ± 0.55^{a}	6.31 ± 0.04^{a}	297.61 ± 10.93^{b}	250.55 ± 10.04^{a}	47.05 ± 2.48^{b}	253.13 ± 2.82^{a}	503.69 ± 10.68^{a}
5:95 (5%)	82.58 ± 0.40^{b}	6.36 ± 0.10^{a}	310.19 ± 5.59^{b}	263.91 ± 6.00^{a}	46.27 ± 5.19^{b}	233.44 ± 9.12^{b}	497.36 ± 9.86^{a}
10:90 (10%)	82.08 ± 0.46^{b}	6.39 ± 0.06^{a}	313.41 ± 2.81^{b}	264.36 ± 8.37^{a}	48.8 ± 5.16^{b}	226.22 ± 9.41^{b}	490.58 ± 10.90^{ab}
15:85 (15%)	81.83 ± 0.45^{b}	6.39 ± 0.07^{a}	314.52 ± 10.61^{b}	268.36 ± 10.15^{a}	46.16 ± 5.93^{b}	204.33 ± 2.58^{c}	472.69 ± 10.06^{b}
100:0 (DMRD6)	70.70 ± 0.52^{c}	4.06 ± 0.00^{b}	397.25 ± 8.99^{a}	208.88 ± 4.21^{b}	188.36 ± 4.79^{a}	56.80 ± 0.71^{d}	265.69 ± 1.22^{c}

[a-d] Means (± standard deviations of three replicates) followed by the same superscript letters in the same column are not significantly different at $p>0.05$.

3.3. Thermal Analysis

The thermal properties (Table 2) were studied by DSC. The gelatinization temperature, ΔH_G, and ΔH_R of DMCNT1 were significantly different ($p<0.05$) from DMRD6. The gelatinization temperature and ΔH_G of blended flours (DMRD6:DMCNT1; 5:95, and 10:90) were not significantly different ($p>0.05$) from DMCNT1, while the T_o of blended flour (DMRD6:DMCNT1; 15:95) was lowered than DMCNT 1 and those of blended flour ($p<0.05$). Moreover, the ΔH_R of DMCNT1 and blended flour of DMRD6:DMCNT1 (5:95) were higher than that of other blended flours ($p<0.05$). The ΔH_R of blended flour (DMRD6:DMCNT1; 10:90) was lower (6.76 J/g) than DMCNT1 (7.49 J/g). These results were indicated that the retrogradation (ΔH_R) of DMCNT1 was reduced with the increasing of the DMRD6. The decreasing of amylose content had affected to the enthalpy of retrogradation value.

Table 2 Gelatinization and retrogradation of DMCNT1, DMRD6, and blended flours (DMRD6 and DMCNT1 at the ratios 5:95, 10:90, 15:85).

DMRD6:DMCNT1	Gelatinization				Retrogradation
(%replacement)	T_o	T_p	T_c	ΔH_G(J/g)	ΔH_R(J/g)
0:100 (DMCNT1)	71.97±0.04^a	77.33±0.20^a	84.45±0.20^a	6.08±0.24^b	7.49±0.51^a
5:95 (5%)	71.79±0.27^a	77.37±0.26^a	84.37±0.37^a	6.09±0.12^b	7.09±0.51^{ab}
10:90 (10%)	71.52±0.21^{ab}	77.49±0.19^a	84.92±0.26^a	6.10±0.31^b	6.76±0.14^b
15:85 (15%)	71.17±0.33^b	77.70±0.17^a	84.81±0.22^a	6.13±0.49^b	6.46±0.45^b
100:0 (DMRD6)	62.10±0.32^c	67.72±0.25^b	77.58±0.02^b	10.24±0.12^a	3.33±0.15^c

$^{a\text{-}c}$ Means (± standard deviations of three replicates) followed by the same superscript letters in the same column are not significantly different at $p>0.05$.

3.4. Evaluation of Cooked rice Spaghetti

Textural characteristics of cooked rice spaghetti samples were measured by using the texture analyser (Table3). The rice spaghetti from DMCNT1 gave the highest firmness and the lowest stickiness. The DMRD6 was unable to make the rice spaghetti due to the fact that its amylose content was too low and very stick to form the spaghetti strand. The firmness of rice spaghetti was decreased with the increasing of DMRD6 level, whereas the stickiness of rice spaghetti was increased. The rice spaghetti made from the blending of DMRD6:DMCNT1 (10:90) had the highest tensile strength (0.120 N).

Cooking time and cooking loss are important parameters of rice spaghetti. Good quality of rice spaghetti should have short cooking time with negligible of solids in cooking water. The cooking time and cooking loss of rice spaghetti samples from this study are shown in Table 3. The cooking time of rice spaghetti made from DMCNT1 was the longest time (9.10 min) and the solid loss was 16.63 %, whilst the rice spaghetti made from blended flour of DMRD6 and DMCN1 (10:90) indicated the lowest cooking time (7 min) and also cooking loss (12.47 %).

Table 3 Textural properties and cooking qualities of rice spaghetti.

DMRD6:DMCNT1 (%replacement)	Firmness (N)	Stickiness (N)	Tensile strength (N)	Cooking time (min)	Cooking loss (%)
0:100 (DMCNT1)	1.590±0.114^a	0.365±0.081^d	0.100±0.010^b	9.10±0.17^a	16.63±1.11^b
5:95 (5%)	1.215±0.035^b	1.201±0.165^c	0.104±0.011^b	8.10±0.17^b	13.38±1.30^c
10:90 (10%)	1.107±0.012^b	1.594±0.068^b	0.120±0.003^a	7.00±0.00^c	12.47±1.21^c
15:85 (15%)	0.625±0.060^c	2.496±0.224^a	0.095±0.010^b	7.00±0.00^c	19.03±1.76^a

$^{a\text{-}c}$ Means (± standard deviations of three replicates) followed by the same superscript letters in the same column are not significantly different at $p> 0.05$.

The surfaces of rice spaghetti samples from all rice flour ratios (Fig. 2A-D) studied by the stereomicroscope are shown in Fig.2. The surfaces of dried rice spaghetti samples from all rice flour ratios were smooth. When the rice spaghetti samples were cooked, the surface of cooked rice spaghetti made from DMCNT1 appeared a unsmooth and uneven surface (Fig. 2E), while the cooked rice spaghetti (DMRD6:DMCNT1; 5:95 and 10:90) were smooth (Fig. 2F, and 2G), and the surface of cooked rice spaghetti (DMCNT1:DMRD6; 85:15) was very sticky (Fig. 2H).

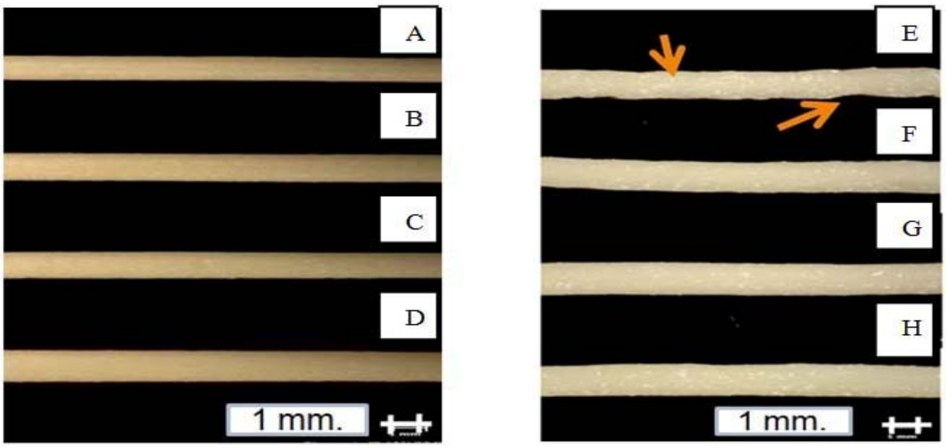

Fig.2: Stereomicrographs of dried spaghetti surface (x10); dried rice spaghetti (A-D) made from DMRD6:DMCNT1 rice flour A)0:100 (DMCNT1), B)5:95, C)10:90, D)15:85. Cooked rice spaghetti made from DMRD6:DMCNT1 rice flour (E-H); E) 0:100(DMCNT1), F)5:95, G)10:90, and H)15:85.

4. Conclusions

The rice spaghetti made from blended flour (DMRD6:DMCNT1; 10:90), indicated the good tensile strength, cooking qualities and the smooth surface. The blending of waxy rice (DMRD6) flour to non waxy rice (DMCNT1) flour affected the decrease of the amylose content, pasting temperature, setback, final viscosity, and enthalpy of retrogradation (ΔH_R) from DMCNT 1. Therefore, replacing of DMRD6 for DMCNT1 could improve the quality of rice spaghetti.

5. Acknowledgements

The authors would like to acknowledge The Royal Golden Jubilee Ph.D. Program, The Thailand Research Fund, for the financial support, and special thanks to Kasetsart University, Thailand, for providing the research facilities.

6. References

[1] H. Wieser and P. Koehler. The biochemical basis of celiac. *Cereal Chem*. 2008, **85**:1-13.

[2] F. S. Shih. Rice Proteins. In: E. T. Champagne(ed). *Rice: chemistry and technology.* 3rd. American Association of Cereal Chemists, Inc. 2004, pp 156-157.

[3] A. Suksomboon and O. Naivikul. Effect of dry-and wet-milling process on rice flour and rice noodle properties. The 32nd Congress on Science and Technology of Thailand (STT.32), October 10-12, 2006, Bangkok. Thailand.

[4] S. Varavinit, S. Shobsngob, W. Varanyanond, P. Chinachoti and O. Naivikul. Effect of amylose content on gelatinization, retrogradation and pasting properties of flours from different cultivars of Thai rice. *Starch/Stärke*. 2003, **55**:410-415.

[5] A. Suksomboon. Effect of dry-and wet-milling processes on rice flour, rice starch and rice noodle properties. *Doctor of Philosophy (Food Science) Thesis*. Kasetsart University, Bangkok, Thailand. 2007.

[6] B. O. Juliano, C. M. Perez, A. B. Blakeney, D. T. Castillo, N. Kongseree, B. Laignelet, E. T. Lapis, V. V. S. Murty, C. M. Paule and B. D. Webb. International cooperative testing on the amylose content of milled rice. *Starch/Stärke*. 1981, **33**:157-162.

[7] AACC. *Approved Methods of the American Association of Cereal Chemists*. 10th. St. Paul, Minnesota. 2000.

[8] J. Fan and B. P. Marks. Effect of rough rice storage condition on gelatinization and retrogradation properties of rice flour. *Cereal Chem*. 1999, **76**(6): 894-897.