CONCLUSION AND RECOMMENDATION

Conclusion

This study was aimed to determine the effect of dry- and wet-milling processes on rice flour, rice starch and rice noodle properties. Dry- and wet-milling processes were used to prepare rice flour from three rice varieties: low amylose (Pathum Thani 1), medium amylose (RD 7) and high amylose (Leuang 11) rice. Rice starch samples were prepared by alkaline extraction method. Chemical, morphological, physicochemical properties and starch molecular structures of dry-milled and wet-milled rice starch and rice flour were determined. The results were concluded as follows:

Difference of milling processes influenced the difference chemical, morphological, physicochemical properties and starch molecular structures in rice starch and particularly rice flour. Dry-milled rice flour from all three rice varieties contained significantly (p<0.05) higher amounts of protein (6.92-7.69 %), fat (0.88-1.05 %) and ash (0.59-0.72 %) than those of wet-milled rice flour, which contained 5.49-6.72 % protein, 0.38-0.58 % fat and 0.26-0.33 % ash. Dry-milled rice flour gave the higher amount of starch damage (8.32-9.11%) than those of wet-milled rice flour (2.99-5.70%). These results indicated that dry-milling process caused more mechanical damage to the starch granules than wet-milling process. As confirmed by the SEM from α-amylase treated samples, the plenty of damaged starch granules were appeared at the fracture surface of the dry-milled flour particles, while rice flour from wet-mill process exhibited the negligible amount of damaged starch granules.

The significant influence of milling processes on the gelatinization parameters was found particularly in the case of rice flour. The results showed that dry-milled rice flour from all rice varieties showed significantly (p<0.05) higher gelatinization temperatures (T_o: 67.12 – 74.00 ^oC, T_p: 74.14 – 79.28 ^oC and T_c: 83.17 – 87.03 ^oC) than those of wet-milled rice flour (T_o: 65.39 – 73.14 ^oC, T_p: 71.89 – 78.24 ^oC and T_c:

82.87 – 86.12 ^{o}C). However, wet-milled rice flour presented significantly (p<0.05) higher ΔH than those of wet-milled rice flour.

The swelling and solubility properties of rice flour and rice starch were investigated. The results showed that the swelling power of rice flour and rice starch was increased with the temperature increase from 55-95 ^{o}C. During heating from 55 ^{o}C to 75 ^{o}C, dry-milled rice flour exhibited the higher swelling power (2.31-10.61 g/g) compared to wet-milled rice flour (1.54-7.76 g/g), while after heating to 85 and 95^{o}C, there are no significantly difference between the swelling power of dry-milled rice flour and wet-milled rice flour. For solubility, the results showed that dry-milled rice flour showed the significantly (p<0.05) higher solubility (1.66-9.30%) compared to wet-milled rice flour (0.82-4.12%) at all test temperature (55 to 95 ^{o}C). For the case of rice starch, the different in swelling power and solubility between dry-milled rice starch and wet-milled rice starch was negligible compared to the case of dry-and wet-milled flour.

Pasting properties determined by RVA showed that there were different of pasting properties among rice varieties. The dry-milled rice flour showed the lower peak viscosity (246.46-338.42 RVU) and lower breakdown (42.00-151.34 RVU) compared to wet-milled rice flour (275.71-363.46 RVU and 84.53-162.08 RVU, respectively). On the other hand dry-milled rice flour presented the higher setback (163.17-251.34 RVU) compared to wet-milled rice flour (106.34-214.46 RVU). It can be concluded that milling process influence pasting viscosity properties in two reasons: (1) through mechanical damaged of starch granules and (2) through the interaction of starch and minor substance i.e. protein and lipid.

With the X-ray diffractometric examination, the milling process showed significantly effect to the crystallinity structure of rice flour. The dry-milled rice flour from all three rice varieties showed significantly (p<0.05) lower relative crystallinity (19.57-20.51%) than those of wet-milled flour (20.81-22.24%).

Starch molecular properties of rice flour and rice starch from the total starch fraction (TSF) and hot-water soluble fraction (HWSF) were determined by SEC-MALLS-RI. The results showed that milling process showed significantly influence on the proportion of high-molecular-weight fraction (fraction I) and the proportion of low-molecular-weight fraction (fraction II). In comparison, dry-milled rice flour and starch from all three rice varieties showed the lower proportion of fraction I, but higher proportion of fraction II compared to wet-milled samples. The results from the multiangle laser light scattering detection (MALLS) showed that the molecular weight (MW) of amylopectin (fraction I) and amylose (fraction II) were 3.42-5.42 x 10^7g/mol and 2.06-3.41 x 10^6, respectively. However, there was no significantly different of the Mw of both amylopectin and amylose was found between dry- and wet-milled samples.

Correlation between chemical properties, starch molecular properties and physicochemical properties of rice flour and rice starch were determined. The results showed that amylose content, the basic chemical property of rice starch and rice flour, showed the significantly correlation with all of physicochemical properties; gelatinization temperature, swelling and solubility at 55^{o}C and RVA pasting viscosities. Moreover, molecular weight of amylose and amylopectin also were significantly correlated with gelatinization temperature and all RVA pasting viscosities. On the other hand, the amount of starch damage, which presented the intensity of starch granule disruption of dry-milled and wet-milled samples, showed the significantly correlation with swelling and solubility at 55^{o}C.

The cooking properties of rice noodle prepared from dry- and wet-milled rice flour from different rice varieties were evaluated. Among three rice varieties, rice noodle from Leuang 11 presented the lowest of WAI of 192.28-218.19% and cooking loss of 2.35-4.91% and the highest cutting force of 98.93-126.99 g and tensile strength of 30.29-40.61 g. Due to the influence of milling process, rice noodle prepared from dry-milled rice flour showed significantly (p<0.05) higher WSI (218.19-277.19%) and cooking loss (4.91-7.02%) compared to those of rice noodle prepared from wet-milled rice flour, which presented the WAI of 192.28-248.28%

and cooking loss of (2.35-6.66%). The results from sensory evaluation determined by QDA (15-cm scale) showed that rice noodle from Leuang 11 exhibited the clearest appearance with the lowest turbidity (9.31-9.35), the highest firmness (7.65-8.69) and elasticity (8.10-9.97) and lowest adhesiveness (5.46-5.87). Moreover, the acceptance data (1-9 hedonic scale) showed that rice noodle from Leuang 11 rice flour showed the highest acceptance score in all attributes (turbidity, firmness, elasticity and adhesiveness) including overall acceptance. Moreover, rice noodle from Leuang 11 both made from dry- and wet-milled rice flour showed none significantly difference in all attributes compared to commercial rice noodle. They showed like slightly to like moderately for turbidity (6.76-7.40), firmness (6.40-7.00), elasticity (5.90-6.90), adhesiveness (6.20-7.00) and overall acceptance (6.40-7.10).

Correlation between rice noodle properties (cooking, texture, and sensory properties) and chemical properties, starch molecular properties and physicochemical properties of rice flour were evaluated. It can be summarized that all rice noodle properties were strongly correlated with amount of amylose content (AM), swelling power at 55^{o}C (SP55) and breakdown (BD).This was possible that we might predict rice noodle properties from the value of swelling power at 55^{o}C and breakdown determined by RVA.

Recommendation

The presented results showed that dry-milled rice flour, particularly the flour from high amylose varieties (Leuang 11) can be used to produce rice noodle, which exhibited good quality of rice noodle similar to rice noodle produced from wet-milled rice flour and commercial rice noodle. However, it is still challenging to study about the properties of dry-milled flour produced from others dry-milling method such as turbo mill, cyclone mill and grinding mill, including the other grinder (or mills) used in the real industry system in order to gain more information and to develop dry-milled rice flour suitable for not only rice noodle, but for various products. From the result, we realized that starch has been recognized to play a key role influence on the properties of rice flour. However, others components such as protein and lipid was also found to affect rice flour properties. Thus, the further study about the role of protein and lipid themselves and the interaction between starch and protein or lipid in rice flour and rice products properties should be accomplished in order to improve the potential of rice flour, typically dry-milled rice flour in the production of various rice products.

Funding Source

This research funding was obtained from the Commission on Higher Education, Ministry of Education.