Discovery, The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

Volume 12 Article 12

Fall 2011

Properties of gluten-free pasta prepared from rice and different starches

Alexandria W. Mertz
University of Arkansas, Fayetteville

Ya-Jane Wang
University of Arkansas, Fayetteville

Properties of gluten-free pasta prepared from rice and different starches

Alexandria W. Mertz and Ya-Jane Wang†*

ABSTRACT

Rice is one of the few cereal products that does not contain gluten. However, the absence of gluten poses problems in the structure of and cooking quality of rice pasta. The objective of this project was to investigate the addition of starch on the physicochemical properties and cooking quality of rice-based pasta. Rice-based pasta was prepared from parboiled long-grain rice flour with the addition of 25% cooked starch from different sources. The color and pasting properties of the ground pasta flour were measured by a chroma meter and a Rapid Visco Analyser, respectively. The pasta was cooked to the optimum cooking time to evaluate its hardness, stickiness, adhesiveness and resilience by using texture profile analysis with a texture analyzer. The water absorption and cooking loss of pasta were determined by weight difference. Overall the addition of starch improved the processibility of rice pasta and enabled the b* value (yellow color) of the uncooked rice pasta to be close to that of the semolina control. The pasting properties of rice pasta containing common corn starch were close to those of the semolina control. Upon cooking, the rice flour control had higher water absorption and greater cooking loss than the semolina control. The addition of starch decreased both the water absorption and the cooking loss relative to the rice flour control. The effect of starch addition on the textural properties of rice-based pasta varied with the type of starch. The addition of waxy starch or tapioca starch resulted in rice pasta with an increase in hardness and stickiness, whereas the addition of common corn, Hylon V, or Hylon VII resulted in rice pasta with a decrease in hardness, stickiness, and adhesiveness. This project demonstrates that the addition of starch significantly changes the color, pasting, cooking and texture properties of rice pasta, and these changes are governed by the type of starch incorporated into the rice pasta. Gluten-free rice pasta can be prepared with properties similar to the semolina pasta by incorporating starches.

* Alexandria W. Mertz will be a senior, in the 2011-2012 school year, in the Department of Food Science.
† Ya-Jane Wang, the faculty mentor, is a University Professor in the Department of Food Science.

MEET THE STUDENT-AUTHOR

Alexandria W. Mertz

I am a senior majoring in food science and minoring in both music and general foods and nutrition. I am originally from St. Charles, Mo. I graduated from St. Charles High School in 2008 and enrolled at the University of Arkansas that fall. I was awarded the Division of Agriculture Land Grant Scholarship, Department of Music Scholarship, and several others. During my stint at the university I have participated in Associated Student Government, Emerging Leaders, LeaderShape, Food Science Club, and the University Symphonic Orchestra. I am currently a member of Alpha Zeta Honors Fraternity.

I would like to thank Dr. Wang, my faculty sponsor, for guiding me through this project and the research process. I would also like to thank Curtis Luckett and Emily Arijaje for teaching me how to use various equipment during this project.

INTRODUCTION

Pasta is an essential staple found in many different cultures across the world. Traditionally pasta is made by mixing durum wheat flour and water. Durum wheat flour has been proven to deliver the highest quality pasta, which is attributed to the gluten that is present in wheat. Gluten is a structural protein that gives pasta cooking stability and firmness or "bite" (al dente). Gluten is composed of glutenin, which gives dough elasticity, and gliadin, which is responsible for making the dough extensible (Sissons et al., 2007).

Unfortunately, many people are affected by celiac disease, which is a genetic disorder resulting in gluten intolerance. Since gluten is found in the majority of cereal products (wheat, barley, and rye), people who suffer from celiac disease have a small selection of grain-based products in which they can consume. The only treatment for celiac disease is to maintain a strictly gluten-free diet. The absence of grains and cereals in a diet can lead to nutrient deficiencies in iron, calcium, folate, and select fat-soluble vitamins. In the United States, approximately one out of every 250 to 500 people is suffering from this disease. In Europe approximately one out of every 200 to 300 people is suffering from celiac disease. The occurrences of celiac disease in Asia and Africa are rare (Sozer, 2009).

Rice is one of the few cereal products that does not contain gluten, i.e. hypoallergenic, and therefore, is a safe food for people with celiac disease to consume. Although it is mainly consumed as whole-grain form, rice can be processed into flour to make gluten-free pasta. However, the absence of gluten poses a few problems in the structure of the pasta and pasta cooking quality. The gliadin and glutenin in wheat gluten form a "network" structure when water is added to wheat dough, which traps the water in the dough and prevents the dissolution of the pasta during cooking. The absence of gluten makes it difficult to achieve a cohesive dough structure, and consequently paste made of rice flour has a different and undesired textural quality.

Starches are widely used in the bakery industry to improve texture and appearance of cereal-based foods. The replacement of wheat starch with rice starch at 3-9% levels resulted in gluten-free breads with similar crust hardness but reduced crumb hardness (Gallagher et al., 2002). Rice flour combined with corn starch and cassava starch were shown to produce high-quality gluten-free bread with good taste and appearance (Sanchez et al., 2002). High amylose starch in the amount of 10-40% was reported to improve cooking tolerance and firmness in retorted pasta and tortilla products (Miller et al., 1986). Because limited work has been done on the improvement of rice-based pasta quality by the incorporation of starch, the objective of this project was to investigate the influences of starch from different botanical sources on the cooking quality of rice-based, gluten-free pasta in an attempt to improve the texture of pasta made from rice flour.

MATERIALS AND METHODS

Rice was provided by the University of Arkansas Rice Processing Program. Starch samples of different sources, including waxy corn, common corn, high amylose corn (50% amylose, Hylon V, and 70% amylose, Hylon VII), potato, and tapioca, were obtained from National Starch LLC (Bridgewater, N.J.). Commercial semolina flour was purchased from a local store to prepare semolina control pasta.

Preparation of Parboiled Rice. Because the slightly darker color of parboiled rice resembles pasta, parboiled rice was used in this study. Long-grain rice was parboiled by soaking 250 g of rough rice in 800 mL of deionized water in a shaker water bath (OLS200, Grant Instruments, Cambridge, UK) at 65 °C for 16 h (Newton and Wang, 2011). Afterwards, soaked rice was removed and autoclaved in an autoclave (Tuttnauer Brinkman, Westbury, N.Y.) at 120 °C and 15 psi for 40 min. The autoclaved rice was placed in a sealed ziplock bag at room temperature for 24 h and then dried at 50 °C for 3 h. The rice sample was dehulled using a Satake dehusker (THU-35, Satake Corp., Hiroshima, Japan), and then milled in a friction mill (MCgill Miller, Brookshire, Texas) for 30 s. The milled rice was seperated into head rice and broken kernels using a double-tray sizing machine (GrainMan Machinery, Miami, Fla.). The head rice was ground into flour for pasta preparation with a cyclone sample mill (UDY Corp., Ft. Collins, Colo.) fitted with a 0.25-mm mesh sieve.

Preparation of Pasta. For the semolina or rice flour control, 75 g of commercial semolina flour or parboiled long-grain rice flour was combined with 65 g of deionized water to form dough. The dough was rolled into a sheet about 1 mm thick using a pasta maker (Imperia Trading S.r.I., C.So Susa, Italy) and then into pasta strands using the fettuccini noodle extrusion attachment. The pasta strands (10 mm in length, 1 mm in width and 0.1 mm in thickness) were placed on a stainless steel metal test tube rack and dried at 90 °C for 1 h. The process was repeated by combining 56 g of rice flour with 19 g of different types of starch to produce different pasta samples. Half of the deionized water was combined with the starch and cooked on a hot plate until the starch was gelatinized, and the other half of the water and the flour were added to form dough (Miller et al., 1986).

Physicochemical Properties of Pasta. The moisture content of pasta was determined by drying 2 g of ground pasta in an oven at 130 °C for 2 h. The color of dried, uncooked or cooked, ground pasta was measured using a Minolta Chroma Meter (CR-100, Osaka, Japan) by recording L*, a*, and b* values. The L* value describes the lightness of the product with a range from 0 (black) to 100 (white). The a* value describes the color of the product in terms of red (positive) to green (negative). The b* value describes the color of the product in terms of yellow (positive) to blue (negative). The pasting properties of ground pasta were determined using a Rapid ViscoAnalyser (RVA, Newport Scientific Pty. Ltd, Warriewood NSW, Australia) operated at 160 rpm according to Approved Method 61-02 (AACC, 2000) with modification. The slurry was prepared by mixing 3.0 g of ground pasta (12% moisture basis) with 25.0 mL of deionized water in a canister (10 % w/w). The slurry was heated from 50 °C to 95 °C at 3 °C/min, held at 95 °C for 10 min, cooled to 50 °C at 3 °C/min, and held at 50 °C for 10 min.

Cooking and Textural Properties of Pasta. Six strands of pasta were weighed, placed in 600 mL of deionized water in a 1000-mL beaker, and cooked in a boiling water bath. The optimum cooking times for the semolina control and rice flour control were 12 and 7 min, respectively. The optimum cooking time for the pasta made with starch was 5 min. The optimum cooking time was defined as the minimum time needed to completely gelatinize starch in the pasta until the disappearance of the white core by visual inspection. The cooked pasta strands were drained and weighed. The water absorption of pasta was calculated as the weight difference and expressed as a percentage of the original sample weight (as is) before cooking. Cooking loss was measured by evaporating the cooking water to dryness in a 100 °C oven and expressed as a percentage of the original sample (as is) (AACC, 2000).

Textural properties of cooked pasta, including hardness, stickiness, adhesiveness, and resilience, were measured using texture profile analysis (TPA) with a TA-XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, N.Y.) after cooking the noodles for the optimum time. The TA-XT2 Texture Analyzer was calibrated with a load cell of 5 kg. A 35-mm cylindrical probe was used to compress a single strand of pasta. Pasta strands were cut into 0.5 cm length before they were compressed. The attachment compressed the pasta strand at a constant rate of 1 mm/s to 70% of the original thickness of the pasta (Petitot et al., 2010).

Data Analysis. The experiment was performed in duplicate and each property was measured at least in duplicate to calculate its mean value and standard deviation.

RESULTS AND DISCUSSION

We noted that it was difficult to sheet the pasta prepared from long-grain rice flour without the addition of starch. The addition of starch to the long-grain rice flour made the dough more pliable and thus easy to sheet. The color properties of uncooked, ground pasta samples are presented in Table 1. Although different values were observed among different pasta samples, the addition of starch resulted in decreased L* value (slightly darker), and increased a* (more reddish) and b* values (more yellowish) for uncooked rice pasta when compared with the rice flour control. Overall the addition of starch enabled the b* value (yellow color) of the uncooked rice pasta to be close to that of the semolina control, indicating the benefit of adding starch to rice besides improving the processibility. The color of cooked pasta samples was also compared after the cooked pasta was dried and ground (Table 2). The addition of starch generally decreased the L* value (slightly darker) of the rice pasta, but the changes in the a* and b* values of rice pasta containing starch were affected by starch type. For example, rice pasta containing potato starch had lower a* (less reddish) and b* (less yellowish) values, whereas rice pasta containing waxy corn starch had higher a* (more reddish) and b* (more yellowish) values when compared with the rice flour control.

The pasting profiles of pasta samples are presented in Fig. 1. The overall pasting profile of the rice flour control was much higher than the semolina control, presumably the higher protein content in semolina flour restricted starch swelling. The rice flour control had very high peak viscosity (2705 cP), breakdown (the difference between peak and trough viscosity) (1340 cP), and final viscosity (2973 cP), whereas the semolina control has little breakdown (101 cP) and low peak (1203 cP) and final (2313 cP) viscosities. Because parboiled rice was cooked during the parboiling process, the rice flour control displayed a higher initial viscosity than the semolina control. The pasting properties of rice pasta containing starch varied with the starch source. The pasting properties of the pasta sample containing common corn starch were similar to those of the semolina control in terms of peak, breakdown, and final viscosities. For rice pasta containing waxy corn, potato, or tapioca starch, it exhibited a higher peak viscosity and a larger breakdown when compared with the semolina control. On the other hand, the rice pasta containing Hylon V or Hylon VII had a very low overall pasting profile, which was attributed to its high amylose content. These results indicate that the pasting profile of rice flour can be modified for specific applications by the addition of an appropriate starch.

When cooked to their respective optimum cooking times, the rice flour control exhibited a slightly higher water uptake and a greater cooking loss compared with the semolina control (Table 3). The greater cooking loss of the rice flour control is not desirable for commercial production because the starchy water is often disposed at a cost as wastewater. The addition of starch not only decreased the water absorption but also greatly decreased the cooking loss of the rice flour control. The addition of potato starch decreased the cooking loss relative to the rice flour control. Both water absorption and cooking loss of rice pasta containing potato starch were close to those of the semolina control.

The textural properties of cooked pasta samples are listed in Table 4. Using texture profile analysis (TPA), the pasta prepared from the rice flour control was softer (lower hardness value), less sticky (lower stickiness value), less adhesive (lower adhesiveness value), and less resilient (lower resilience value) than the semolina control. The addition of starch had different impacts on the textural properties of rice pasta. The incorporation of waxy corn starch or tapioca starch to the rice flour resulted in pasta with significantly harder, stickier, more adhesive, and more resilient texture. In contrast, common corn starch and high amylose corn starch (Hylon V and VII) produced pasta of softer, less sticky, less adhesive, and less resilient texture. Overall, rice pasta containing potato starch had the hardness more close to that of the semolina flour control.

The results of this study indicate that different starches can be combined to improve the texture and pasting and cooking properties of rice-based pasta to have properties similar to the semolina pasta. The use of waxy corn starch or tapioca starch could reduce the cooking loss and increase the hardness, area of peak force, stickiness, adhesiveness, and resilience of rice pasta; whereas the opposite effects would result by incorporating common corn starch or high amylose corn starch (Hylon V and VII) into rice flour.

In conclusion, this project demonstrates that the addition of starch significantly changes the color, pasting, cooking and textural properties of rice-based pasta, and the changes are governed by the type of starch incorporated into the pasta. Knowing how starch affects the properties of rice pasta will help the improvement and future development of hypoallergenic pasta and cereal products, thus expanding the foods available to those suffering from gluten intolerance.

ACKNOWLEDGEMENTS

I would like to thank Dr. Ya-Jane Wang for all of her support, motivation, and advice during this project. I would also like to thank the University of Arkansas Rice Processing Program for providing the rice used for this project. I would like to express my gratitude to Dr. Jean-Francois Meullenet for demonstrating the use of the texture analyzer. Also, my gratitude is extended to Curtis Luckett and Emily Arijaje for teaching me how to use various equipment during this project.

LITERATURE CITED

AACC. 2000. Approved Methods of the American Association of Cereal Chemists 10th. Method 61-02. AACC International. St. Paul, Minn.

Gallagher, E., O. Polenghi, and T.R. Gormley. (2002). Improving the quality of gluten-free breads. Farm and Food, 12:8-13.
Miller, B. J., H. Bell, and E. Wojcak. (1986). Retorted paste products containing high amylose starch. U.S. Patent 4,590,084.
Newton, J., and Y.-J. Wang. 2011. Effects of cultivar and processing condition physicochemical properties and starch fractions in parboiled rice. Cereal Chem. (accepted).
Petitot, M., L. Boyer, C. Minier, and V. Micard. (2010). Fortification of pasta with split pea and faba bean flours: pasta processing and quality evaluation. Food Res. Int., 43:634-641.
Sanchez, H. D., C.A. Osella, and M.A. De La Torre. (2002). Optimization of gluten-free bread prepared from cornstarch, rice flour, and cassava starch. J. Food Sci., 67:416-419.
Sissons, M. J., H.N. Soh, and M.A. Turner. (2007). Role of gluten and its components in influencng durum wheat dough properties and spaghetti cooking quality. J. Sci. Food Agri., 87:1874-1885.
Sozer, N. (2009). Rheological properties of rice pasta dough supplemented with proteins and gums. Food Hydrocolloids, 23:849-855.

Table 1. Color properties of uncooked pasta samples as measured by a chroma meter[1]

Pasta sample	L*[2]	a*	b*
Semolina flour	89.6 ± 0.5	-1.1 ± 0.2	14.4 ± 0.2
Rice flour	90.9 ± 0.4	-0.6 ± 0.2	6.4 ± 0.5
Rice flour + waxy corn starch	87.8 ± 0.3	0.7 ± 0.1	13.5 ± 0.0
Rice flour + common corn starch	84.1 ± 1.7	0.6 ± 0.1	13.1 ± 0.2
Rice flour + Hylon V corn starch	86.3 ± 0.2	0.7 ± 0.3	14.0 ± 0.3
Rice flour + Hylon VII corn starch	88.9 ± 0.3	0.7 ± 0.1	12.9 ± 0.3
Rice flour + potato starch	88.3 ± 0.2	0.7 ± 0.0	12.9 ± 0.2
Rice flour + tapioca starch	88.2 ± 0.4	0.8 ± 0.0	13.0 ± 0.1

[1] Mean of duplicate measurements ± standard deviation.
[2] L* value describes the lightness of a product with values ranging from 0 (black) to 100 (white); a* value describes the color of a product, ranging from red (positive values) to green (negative values); and b* value describes the color of a product, ranging from yellow (positive values) to blue (negative values).

Table 2. Color properties of cooked pasta samples as measured by a chroma meter[1]

Pasta sample	L*[2]	a*	b*
Semolina flour	80.0 ± 1.6	-0.2 ± 0.02	22.3 ± 0.4
Rice flour	81.4 ± 0.2	2.3 ± 0.02	18.7 ± 0.0
Rice flour + waxy corn starch	75.3 ± 0.3	3.4 ± 0.02	21.5 ± 0.0
Rice flour + common corn starch	74.9 ± 0.6	2.2 ± 0.03	18.5 ± 0.2
Rice flour + Hylon V corn starch	78.7 ± 0.1	2.5 ± 0.01	20.2 ± 0.0
Rice flour + Hylon VII corn starch	72.4 ± 0.1	2.5 ± 0.04	19.0 ± 0.1
Rice flour + potato starch	68.9 ± 1.0	1.6 ± 0.04	15.4 ± 0.3
Rice flour + tapioca starch	81.7 ± 0.3	1.2 ± 0.01	17.7 ± 1.3

[1] Mean of five measurements ± standard deviation.
[2] L* value describes the lightness of a product with values ranging from 0 (black) to 100 (white); a* value describes the color of a product, ranging from red (positive values) to green (negative values); and b* value describes the color of a product, ranging from yellow (positive values) to blue (negative values).

Table 3. Cooking properties of pasta samples[1]

Pasta sample	Water Absorption (g/g)	Cooking loss (g/g)
Semolina flour	1.06 ± 0.00	0.04 ± 0.01
Rice flour	1.22 ± 0.04	0.22 ± 0.09
Rice flour + waxy corn starch	0.57 ± 0.01	0.02 ± 0.00
Rice flour + common corn starch	0.75 ± 0.04	0.06 ± 0.02
Rice flour + Hylon V corn starch	0.53 ± 0.05	0.05 ± 0.00
Rice flour + Hylon VII corn starch	0.71 ± 0.00	0.14 ± 0.00
Rice flour + potato starch	1.01 ± 0.05	0.06 ± 0.01
Rice flour + tapioca starch	0.77 ± 0.03	0.04 ± 0.01

[1] Mean of duplicate measurements ± standard deviation.

Table 4. Textural properties of pasta samples[1]

Pasta Sample	Hardness (N)	Stickiness (N)	Adhesiveness (N•sec)	Resilience
Semolina flour	83.5 ± 10.8	-8.2 ± 1.1	-3.8 ± 1.2	-0.10
Rice flour	73.9 ± 17.5	-5.1 ± 1.6	-1.0 ± 0.5	-0.07
Rice flour + waxy corn starch	106.9 ± 7.6	-12.4 ± 1.0	-2.4 ± 1.0	-0.12
Rice flour + common corn starch	59.6 ± 14.2	-4.7 ± 0.2	-0.7 ± 0.0	-0.08
Rice flour + Hylon V corn starch	41.8 ± 6.7	-3.3 ± 1.4	-0.6 ± 0.2	-0.08
Rice Flour + Hylon VII corn starch	56.0 ± 16.6	-2.7 ± 1.9	-0.6 ± 0.2	-0.05
Rice flour + potato starch	98.2 ± 14.6	-4.0 ± 0.9	-0.7 ± 0.2	-0.04
Rice flour + tapioca starch	126.3 ± 8.8	-12.2 ± 0.9	-3.9 ± 0.6	-0.10

[1] Mean of five measurements ± standard deviation.

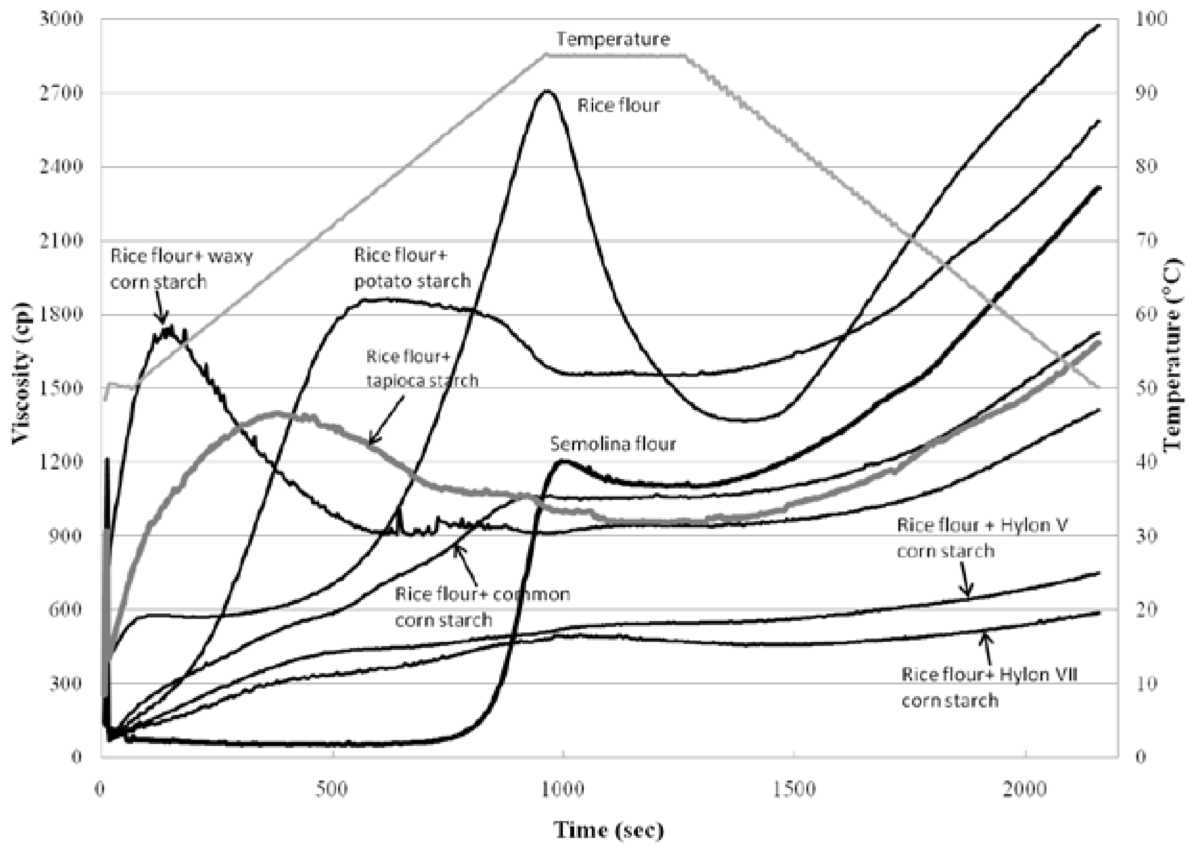

Fig. 1. Pasting properties of pasta samples as measured by a Rapid ViscoAnalyser. Standard deviation is ±50 cp.