Effects of Rough Rice Storage Conditions on the Amylograph and Cooking Properties of Medium-Grain Rice cv. Bengal

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ABSTRACT

Rough rice (cv. Bengal) was stored at four moisture contents (8.8, 10.7, 12.9, and 13.6% MC) and three temperatures (3, 20, and 37°C) for up to six months. The amylograph overall paste viscosity of the milled rice increased during storage. This increase was most apparent in all samples stored at 37°C. For rice stored at 20 and 37°C at all MC levels, a 30–50% increase in peak viscosity (PV) was observed during the first three months of storage. PV subsequently leveled off for rice stored at 12.9 and 13.6% MC but declined for samples stored at 8.8 and 10.7% MC. The final viscosities also increased during storage. The water-absorption ratio of the samples during cooking in excess water increased by an average of 15% over six months of storage. The amylograph and cooking properties were significantly affected (P < 0.05) by rough rice storage duration, temperature, MC, and their respective interactions.

MATERIALS AND METHODS

Sample Preparation

Rough rice (cv. Bengal) was harvested from the University of Arkansas Rice Research and Extension Center, Stuttgart, AR, during September 1995. Immediately after harvest, the rough rice samples were dried in a dockage tester (Carter-Day Co., Minneapolis, MN) and immediately air-dried at room temperature (=20°C) over a 14-day period. Samples were taken after different drying durations to yield rough rice with 8.8, 10.7, 12.9, and 13.6% MC (wb). The MC of the rice was measured by drying duplicate samples for 24 hr in an air oven at 130°C (Jindal and Siebenmorgen 1987). Each of the four lots of rice at the different MC levels was split into three 10-kg portions using a Boerner divider (model 34, Seedburo Equipment Co., Chicago, IL) and placed in sealed plastic buckets. The buckets were held at –10°C for four months before storage at different treatment temperatures. It was assumed that this temporary, low-temperature storage of the dry rice resulted in no significant changes in functional properties.

At each sampling time, the rough rice was hulled and milled in a laboratory milling system. A 150-g portion of rough rice was de-hulled in a McGill sample sheller (Rapsco, Brookshire, TX). The resulting brown rice was milled in a McGill No. 2 mill operated with a 1.5-kg weight positioned 15 cm from the mill saddle centerline on the mill lever arm. Head rice was separated from the broken rice in a Seedburo sizer fitted with two 4.0-mm (0.16 in.) sizing plates. Because MC affects the degree of milling, milling times were established by milling samples from each lot after different drying durations and analyzing the total lipids with a Soxtec fat extractor (Tecator AB, Hoganas, Sweden) with petroleum ether as the solvent (Soxtec 1983). Total lipids were plotted against milling times for each lot. From these plots, the milling durations that yielded rice with 0.75% total lipids were calculated and used for testing. These milling durations ranged from 35 sec for rice at 13.6% MC to 100 sec for rice at 8.8% MC. HRY was computed as the mass percentage of head rice relative to 150 g of the starting rough rice.

Amylography, using a Brabender Viscograph-E (C. W. Brabender, South Hackensack, NJ), was conducted in duplicate according to approved method 61-01 for milled rice (AACC 1995), using a heating rate of 3°C/min and a cooling rate of 3°C/min. The head rice was ground in a cyclone mill (Udy Corp., Fort Collins, CO).
CO) fitted with a 0.5-mm screen. The MC of the ground rice was measured using an air-oven method (Juliano et al. 1985). Slurry (500 g) containing 8% dry matter in water was used for the amylography. The peak and final viscosity (PV and FV, respectively) data from each sample were recorded and analyzed.

For cooking properties, the water-absorption and volume-expansion ratios of the rice when cooked in excess water were measured in duplicate (Bhattacharya and Sowbhagya 1971). A wire basket (4.3 cm i.d. x 7 cm) containing 20 g of head rice was placed in a 250-mL beaker with 150 mL of deionized water at an initial temperature of 20–25°C. The beaker was placed for 20 min in a cooker filled with boiling water. After removal of the basket from the cooker, the excess water was drained for 10 min before weighing. The water-absorption ratio was computed as the increase in mass of the cooked rice divided by the initial mass of the raw rice. The volume-expansion ratio was computed as the ratio of the cooked rice height to the raw rice height.

Data Analyses

Analysis of variance was performed to determine the variables that contributed significantly (α = 0.05) to the PV, FV, and water-absorption ratio. Subsequently, models describing the amylograph and cooking properties as functions of storage duration, storage temperature, and MC of rice were constructed using the general linear model procedure (SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Changes in Functional Properties

During storage at all temperatures, HRY did not change significantly with time. The mean HRY for all samples was 67.92%, with a standard deviation of 0.82%. However, as seen in previous research, the amylograph properties of the rice changed with rough rice storage duration and temperature. For example, rice at 8.8% MC had a PV of 620 BU at the beginning of the storage study (Fig. 1). PV increased to 805 BU after one month of storage at 37°C and reached a maximum of 890 BU after three months. PV began to decrease after three months. At 8.8% MC and 20°C, PV increased from an initial 620 to 770 BU at two months and began decreasing after two months. At 3°C, less overall change in PV was observed, with an increase from 620 to 760 BU at one month of storage and then a decrease that leveled off to ~680 BU. For the most part, similar trends were observed in the other lots at different MC levels. At this time, the decrease in PV after three months of storage cannot be explained. Consequently, future work will seek to explain the fundamental cause of this phenomenon.

For FV, all samples stored at 37°C exhibited a general increase with longer storage duration (Fig. 2). The increase was most rapid during the first three months of storage. For example, with the 8.8% MC rice the FV increased from 640 BU at the beginning of the storage to 855 BU after three months and leveled off after that. No appreciable change was observed in the samples stored at 20 and 3°C.

With respect to cooking properties, all of the rice stored at 37°C showed an increase in the water-absorption ratio during the first three months of storage (Fig. 3). However, after three months the water-absorption ratio of all four lots either leveled off or declined. At 20°C, the change in water absorption for all samples was not much different from the samples stored at 3°C. There was no definite trend observed for the volume-expansion ratio of the stored rice; therefore, these data are not reported here.

Fig. 1. Effect of storage temperature, duration, and moisture content (MC) on amylograph peak viscosity of rice cv. Bengal.
Fig. 2. Effect of storage temperature, duration, and moisture content (MC) on amylograph final viscosity of rice cv. Bengal.

Fig. 3. Effect of storage temperature, duration, and moisture content (MC) on water-absorption ratio during cooking of rice cv. Bengal.
Changes in milled rice (cv. Bengal) functionality during storage are affected not only by storage duration and temperature but also by the rough rice storage MC. The effect of storage temperature and duration on the amyllograph and cooking properties were consistent with previous research; paste viscosities and water absorption during cooking increased with storage duration and temperature. Furthermore, statistical analyses showed a significant contribution of storage MC to changes in functional properties of cv. Bengal during storage. Interactions among the different variables tested also were significant. The resulting polynomial models suggest that rice aging is a complex process. Predictive models for aging would be useful in managing rice storage conditions that will produce rice with specific and consistent functional properties. Consequently, further investigations into the fundamental mechanism for these changes are needed. Additionally, the influence of cultivar and postharvest processing conditions need to be addressed.

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LITERATURE CITED


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