Factors Affecting Rice Milling Quality

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Overview of Rice Milling

In Arkansas, rice is commonly harvested at moisture contents of 13 to 22%. Rice above 13% moisture content is unsafe for long-term storage and must be dried to 12 to 13% moisture content before being stored. Once rice has been dried to this level, the milling process can begin.

Dried “rough rice” (rice with the hull still attached) is first cleaned to remove foreign material, such as weed seed, leaves, and other foreign matter. Next, rough rice is hulled to produce “brown rice.” Immediately after hulling, brown rice is milled to remove the bran layer and germ by friction and/or abrasive action, which results in “white rice.” The hull and bran represent 20% and 10% of the original rough rice mass, respectively.

The remaining white rice, milled rice yield (MRY), is expressed as a percentage of the original dried rough rice mass, and typically ranges from 68 to 72%. White rice is comprised of head rice (defined as those kernels retaining three-fourths or more of their original length) and broken kernels (brokens). After brokens are removed, only head rice remains. Head rice yield (HRY) is the mass of head rice expressed as a percentage of the original rough rice mass. Head rice yield can vary from 0 (all kernels are broken) to a maximum of approximately 70% (no kernels broken). Milling quality is often expressed as a ratio of head rice yield to milled rice yield. For example, a 58/70 value would indicate a head rice yield of 58%, milled rice yield of 70%, and 12% broken kernels (the difference between the two values).

The amount of bran remaining on milled kernels is known as the “degree of milling.” Whiteness, as measured with a color meter, is sometimes used to indicate degree of milling. A more common method for quantifying degree of milling is measuring the amount of lipids, or oil, on the surface of milled kernels. Since bran is approximately 20% lipids, the surface lipid content of milled rice is directly related to the amount of bran remaining on milled kernels. The more rice is milled, the whiter rice appears, surface lipid content decreases, and both MRY and HRY decrease. While there is currently no accepted standard for measuring degree of milling, most commercially-milled rice must meet some form of degree of milling specification.

Production Factors Affecting Milling Quality

Milling quality can be influenced by any factor that affects kernel strength, which is ultimately responsible for the kernel withstanding the rigors of hulling and bran removal without breaking apart.
1. Disease: Rice blast, sheath blight, and kernel smut can reduce milling quality. Kernel smut can also cause discoloration of kernels, resulting in problems during parboiling.

2. Insects: Can have detrimental effects on rice quality. Most notable is the rice stink bug, which bores into the kernel during development, leaving a black spot on the kernel surface known as “peck.”

3. Harvest moisture content: Head rice yield typically varies with the moisture content at which rice is harvested. The harvest MC at which HRY is maximum, under Arkansas weather conditions, is approximately 19 to 21% for long-grain cultivars and 22 to 24% for medium-grains. Harvesting at MCs greater than or less than optimal can result in decreased HRY, as illustrated in Figure 1. As rice matures, kernels on a panicle exist at very different MCs, representing various maturity and kernel strength levels. Some kernels are immature or “green” (MCs greater than 22%) while others are “dry” (MCs lower than 14%). Immature kernels (Figure 2) are typically weak in structure and often break during milling. Rapid rewetting of dry kernels, through exposure to rain or high relative humidity air, causes a rapid expansion at the kernel surface resulting in the formation of fissures (Figure 3). Based strictly on maximizing head rice yield, it is generally recommended to harvest rice at the optimal MCs indicated above. However, drying costs increase with harvest MC, which could make the economic optimum harvest MC slightly less than the optimal MC for maximizing head rice yield. Brokens produced during milling are generally the result of immature, chalky, or fissured kernels; all of which are weak and break due to the forces applied to kernels in order to remove the bran. Broken kernels reduce milling yield.

4. Nighttime air temperature effects: Increasing nighttime air temperatures during certain kernel reproductive stages will dramatically increase chalkiness and reduce HRYs. Chalkiness (Figure 4) reduces kernel strength and thus directly relates to milling yield reduction and visual appearance of the milled rice. The most dramatic impact on milling quality is that peak head rice yields will be reduced substantially when high nighttime air temperatures are incurred during kernel filling.

Summary

In summary, any factor that causes a reduction in the strength of kernels and the ability of kernels to withstand the hulling and milling processes will impact milling yield. These factors include those during production, such as diseases, insects, and high nighttime air temperatures. The moisture content at which rice is harvested can also have a dramatic effect on milling quality, with head rice yield reductions occurring by harvesting at moisture contents greater or lower than optimal.
Figure 1. Parabolic relationship between head rice yield and harvest moisture content of long-grain cultivar Cypress sampled over a range of harvest moisture contents from Keiser, AR.

Figure 2. Hullled immature kernels, which are generally weak in structure and prone to breaking.
Figure 3. Fissured kernel due to rapid moisture adsorption.

Figure 4. Chalky kernels – chalk appears opaque white and may affect a particular region of a kernel (left) or the entire kernel (right).