Influence of Postharvest Processing on Rice Quality

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Recent trends in rice use in the United States have made it necessary to reevaluate the criteria used to define rice quality. There are several different ways that we can, and perhaps should, view postharvest research, and problem solving in general, as related to rice quality. These approaches all involve viewing postharvest processing of rice as a system. However, I would like to propose different ways that we can define the "system."

Trends in Rice Use

In 1996-97, the United States consumed approximately 60% of its domestic rice production, exporting the remaining 40%. Since 1990, 72% of domestic consumption has been for food use, while the remainder can be categorized as for brewers's use (14%), seed (4%), and residual (9%). Of particular note is that during the 1990s, the brewers', seed, and residual category levels have shown no growth or have slightly declined. However, the food use category has increased at an annual rate of 4% since 1990 and has doubled in the past 15 years.

These trends certainly have an effect on how one defines "quality" in the rice industry. In the past, rice was typically considered to be predominantly a grain commodity for export. Quality for this mode of disappearance was defined by quantifiers such as foreign and fine material content, bulk density or test weight, and usually head rice yield. With the increased domestic use of rice, particularly for food and beverage uses, the quality definitions must be extended to include processing measures of quality.

Even with the trend of increased food use of rice, there remains strong diversity in rice disappearance modes. Accordingly, the term *rice quality* is dependent on many qualifiers, including: the location of the user of this term or user's company in the production chain, the business function or type of company that the user is employed by, the type of process the user is most concerned with, and the educational or job-related discipline that the user represents.

Independent of these qualifiers, practically any quality parameter is influenced by many interrelated factors. Because of this and the many diverse opinions and definitions of quality, it would seem logical to treat the postharvest area as a system, which can be defined as "an assemblage or combination of things or parts forming a complex or unitary whole." However, there can also be many views and interpretations of how to apply this systemic approach to the rice postharvest area. The following sections look at three aspects of the systemic approach.

Measurement Scale

The system that one defines to describe the postharvest area can be very different depending on many of the factors listed above in determining the definition of quality. To many, a system is a series of large storage bins; to others, a series of rail cars or truckloads of rice; to others, a set of samples taken from a single lot of rice; and finally, to others, the individual kernels making up a sample. The term *measurement scale* is used here to indicate the level at which one views a system when quantifying or measuring properties or conditions that may determine quality.

In our rice processing research program at the University of Arkansas, we have increasingly come to define our measurement scale as an individual kernel, i.e., we try to view the "system" as a compilation of individual kernels, each with its own properties and states. One of the primary reasons for this has been the use of a fairly recent technological development, the individual kernel moisture meter. The kind of distribution of kernel moisture contents that can be observed within a sample at harvest is given in Figure 1. While the average moisture content of this sample was 19.2%, wb, it is clear that individual kernel moisture contents ranged from 10 to 30%. Our studies have shown that even after drying and extended bulk storage to allow "full equilibration," a wide range of kernel moisture contents remains.

Another way to characterize a system of individual kernels is through the distribution of kernel dimensions. Figure 2 indicates the distributions of kernel thicknesses that can be observed for several long-grain cultivars. Just as with kernel moisture contents, a wide range of kernel thicknesses can be found within a bulk.

The manner in which a bulk of rice responds to a postharvest treatment is dictated by the collective response of the individual kernels, which would be expected to vary with the individual composition and physical properties of each kernel.

An example of how individual kernels can respond differently to a postharvest treatment is illustrated in Figure 3. As part

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of one of our recent studies investigating the performance of commercial milling systems, a long-grain rice cultivar was milled in a Satake BA 15 single-break milling system to three degree-of-milling levels. The milled rice was then fractionated based on kernel thickness, and the surface lipid concentration for each fraction was measured. Figure 3 indicates that the thinner kernels were not milled to the same surface lipid content as the thicker kernels, particularly at the lower degree-of-milling levels. Figure 4 shows the corresponding protein levels of each of the thickness fractions. Higher protein contents were measured for thinner kernels than for thicker kernels, even after correcting for the higher lipid content of the thinner kernels.

This work has shown that a wide variation in kernel properties can exist in milled rice. Measurements at a higher measurement scale (e.g., of bulk, unfractionated samples) did not reflect the lack of homogeneity at the individual kernel level. These variations affected the milled rice product uniformity, which could in turn affect subsequent processing operations. This particular study illustrates an instance in which it was beneficial to view the system at the individual kernel level.

Scope of Consideration

Another view that might be proposed for defining the postharvest system is the scope of the unit operations that one would include in a system. Many projects and studies have concentrated on particular operations such as drying or milling. The effects of these particular operations are typically assessed in terms of some aspect of quality. For instance, in drying, this variable is usually head rice yield. However, as discussed above, rice quality has many facets and can be affected by many variables. The effect of drying on other quality attributes has traditionally not been addressed or has not been addressed in a quantitative way.

When considering the rice postharvest system, the scope of consideration should ultimately encompass all operations and

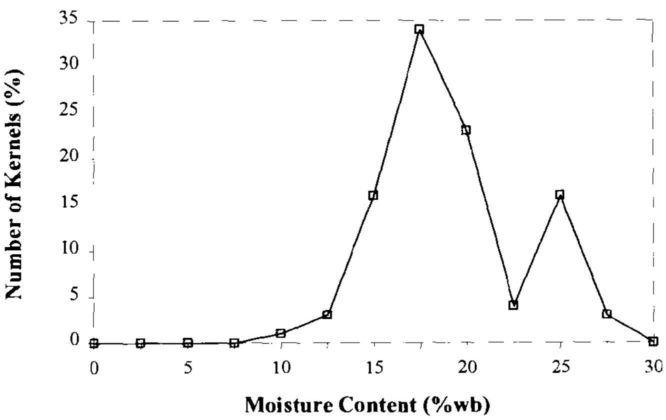

Fig. 1. Kernel moisture content distribution for cultivar Cypress long-grain rice harvested at 19.2% wb. The bimodal moisture content distribution is a characteristic of rough rice at harvest.

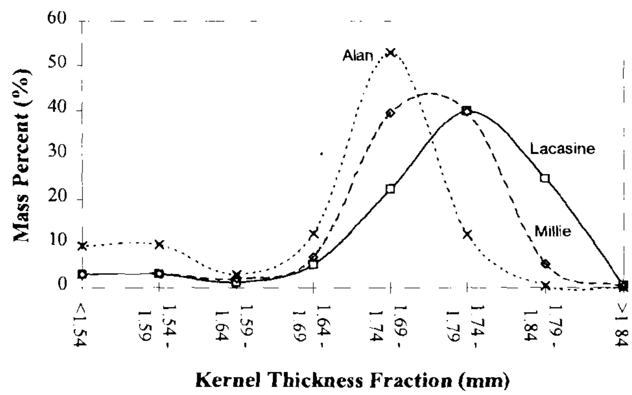

Fig. 2. Mass distributions of head rice kernel thickness fractions for three long-grain cultivars reflect the natural variability present within a bulk sample.

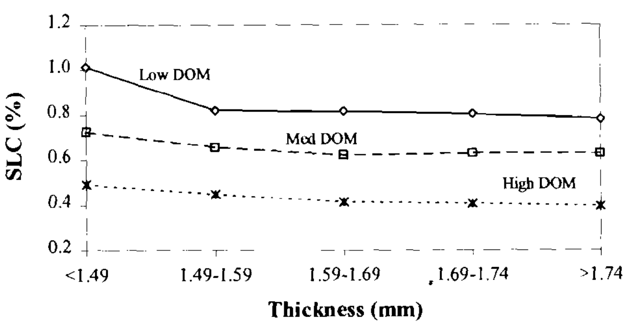

Fig. 3. Surface lipid concentrations (SLCs) of different thickness fractions vary within a bulk sample milled to different degree-of-milling (DOM) levels. The thinner kernels are not milled to the same SLC as the thicker kernels at the lower DOM levels.

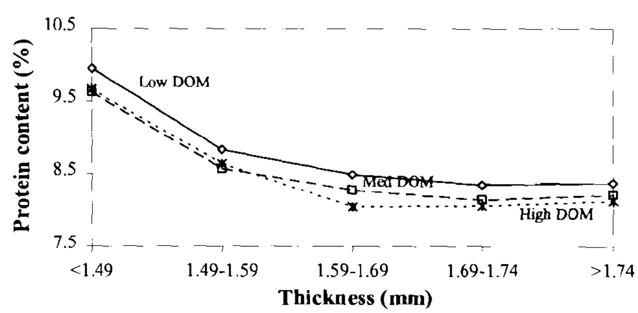

Fig. 4. Protein content of different thickness fractions vary within bulk samples of milled rice that were milled to different degree-of-milling (DOM) levels. After milling, the thinner kernels have significantly higher protein contents than other thickness fractions.

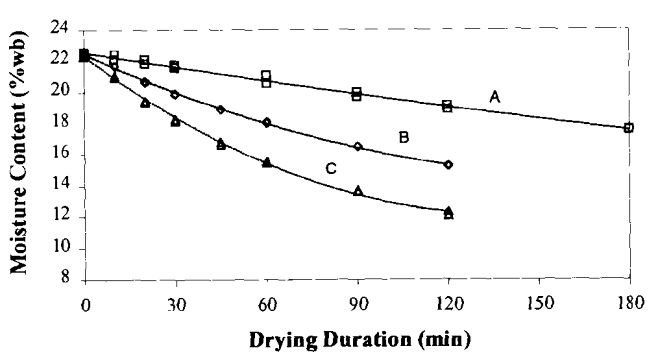

Fig. 5. Moisture content curves resulting from drying cultivar Bengal medium-grain rice at conditions A (43°C, 38% rh), B (52°C, 25% rh), and C (60°C, 17% rh).

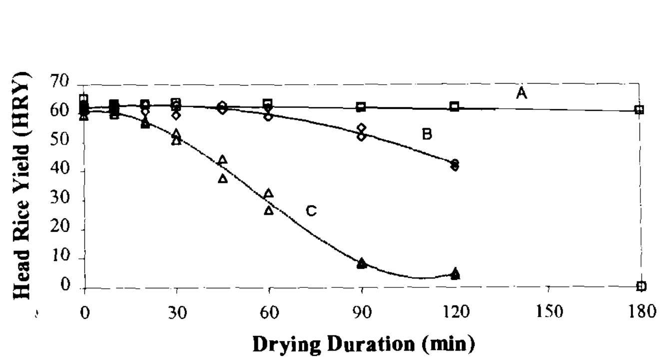

Fig. 6. Head rice yield curves corresponding to the drying durations and conditions given in Fig. 5.

processes, beginning with characterizing the state of the rice at harvest and progressing through sensory evaluation at the final consumption stage. This is often a difficult task, requiring careful tracking and sample identification as well as coordination among various groups at various levels throughout the postharvest system.

An example that we in our labs are specifically addressing along these lines is the effect of diseases such as blast and sheath blight, which are generally known to affect the development of the rice kernel. Plant pathologists agree that severe cases of these diseases can affect "quality." However, other than reductions in head rice yield, which are not well documented, the total picture of quality reduction is not well known. Since these are developmental diseases, it is reasoned that they could also affect the composition of the kernel, which in turn could affect drying rates, paste viscosities, thermal properties, etc. The effects of these diseases need to be quantified in terms not only of milling quality, but also of end-use functionality.

Another example of implementing the systems approach by broadening the scope of consideration is through an extension of typical drying studies. Typically, grain drying studies measure the drying rate to ascertain information on dryer capacity and burner rating. In rice drying, head rice yield is also often included because of its paramount importance. Figures 5 and 6 illustrate drying rate and head rice yield reduction curves, respectively, that were generated by drying rice under three air conditions ranging from gentle to fairly severe. While such information is very useful in depicting the influence of drying on the physical quality parameter of head rice yield, the scope of consideration should be extended to be more representative of the entire postharvest system. The scope should comprise a full physicochemical property characterization before drying and a quantitative assessment of the effect of drying on functional and sensory attributes as well. While these additional tests are costly and require planning and coordination, the results could indicate possible reasons for differences in processing behavior between lots of rice of the same variety from the same harvest location.

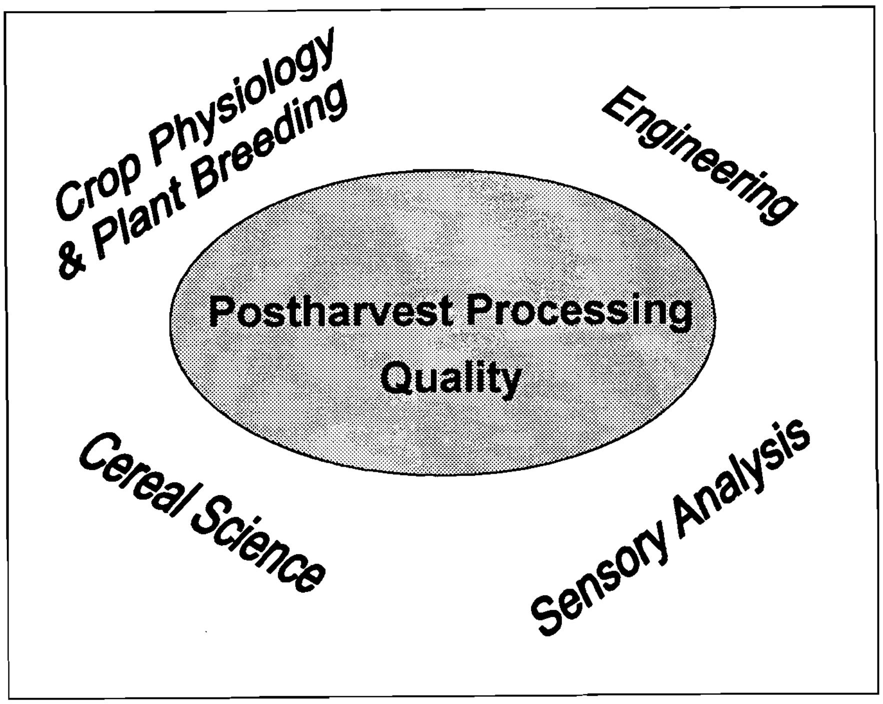

Fig. 7. The systemic approach involves integration of the various disciplines associated

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Disciplinary Involvement

Interpreting or applying the systemic approach also involves integrating the various disciplines associated with postharvest quality. Figure 7 illustrates these various disciplines. Often, a person working in the rice postharvest area has experience in a number of disciplines, which is often necessary and advantageous. It is clear that, for us to address the rice postharvest area as a system, as outlined above, many different disciplinary backgrounds are required, which themselves form a system.

One particularly fertile area for multidisciplinary involvement is the integration of food engineering and cereal science. Typical engineering topics applied to postharvest work include the quantification of drying rates and head rice yield reductions. Additionally, mathematical predictions of stress resulting from moisture gradients during drying can be formulated using finite element analyses. However, these predictions are only as good as the accuracy of the input (material property values) into the models. A fundamental description of the material and the manner in which the material changes during moisture transfer is needed for accurate prediction of stress development. The area of cereal science quantifying glass transition temperatures and the states of the material below and above this temperature would appear to be particularly pertinent in fulfilling this need. This would certainly seem to produce a more fundamentally sound explanation and prediction of what occurs during moisture transfer, which is inherent not only in drying, but in so many other processes as well.

Conclusion

There are many ways to view the rice postharvest area as a system, particularly with the overall constraint that "quality," in its many definitions and interpretations, must be preserved through all operations. Applying all of these views could be necessary to fully understand the vast array of ways in which quality can be affected.