Developing rice varieties with high grain quality in Africa: Challenges and prospects

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Abstract
The demand for rice in Africa continues to outstrip production with the continent importing nearly 10 million tonnes annually. Although there are rice development programs in several African countries, this gap widens yearly. In most African countries, the emphasis in the rice programs has been on increasing yield and enhancing stress tolerance to the detriment of grain and cooking qualities. The reasons for this include the lack of appreciation of the importance of superior grain quality, the unavailability of the appropriate testing equipment, and an absence of personnel with the requisite knowledge in many African countries. Consequently, rice varieties are developed, field-tested and released without reference to their milling potential, amylose content, gelatinization temperature, gel consistency, chalkiness, pasting characteristics, cooked rice texture and aroma. Consumer acceptability trials are also often not carried out. Although these varieties are usually able to satisfy farmer requirements, they are often unable to compete on local markets with imported rice. As a result, lower prices are paid for locally produced rice, reducing the incentive for local production and consequently the success of African rice improvement initiatives.

Introduction

Rice (*Oryza sativa*) provides the staple food over 3 billion people, representing nearly half of the world's population. In Africa, there is a growing deficit between production and consumption, with the continent importing over 10 million tonnes of rice annually. In the major rice-consuming countries, grain quality characteristics dictate the market value of the commodity and play an important role in the development and adoption of new varieties (Fitzgerald *et al.*, 2008, 2009; Champagne *et al.*, 1999; Juliano, 2008). In Africa, although many countries have rice development programs, the required attention has not been paid to the eating and cooking qualities of the grain.

Consequently, rice produced in many African countries is unable to compete with imported rice and locally produced rice is increasingly ceding market share to imports. Grain quality includes such traits as physical appearance, cooking and sensory properties, as well as nutritional value (Fitzgerald *et al.*, 2009). The relative importance of each characteristic depends on local preferences and the kind of dish to be prepared from the rice.

What is good-quality rice?

Grain quality may have different meanings to different operatives in the rice value chain — farmers, processors, millers, nutritionists, policy-makers, marketers, purchasers and consumers. Each may have a slightly different opinion as to what good-quality rice is, but generally it should have the following characteristics:

- Little or no chalk, except for Arborio rice and varieties for *sake* production
- translucent appearance
- uniform coloration and good for the purpose for which it has been produced (white for raw-milled rice and with a yellowish tinge for parboiled rice)
- A high percentage of whole unbroken grains
- The shape (length and length–width ratio) should be right for the variety type
- Excellent cooking properties — should satisfy the consumers' preference for cooked rice for the particular kind of food preparation.

Chalkiness

Chalkiness is a grain-appearance trait that affects consumer acceptance of rice. Chalky grains have opaque spots in the endosperm that may differ in position and size. Chalkiness may be referred to as 'white belly', 'white core' or 'white back', depending on its location within the endosperm. It almost invariably detracts from overall appearance and generally results in lower milling yields (Yamakawa *et al.*, 2007). This is because chalky grains are weak and tend to break on milling. An exception to this is in parboiled rice, where the process tends to strengthen the grains. However, even in parboiling, excessive chalkiness is undesirable as the nonuniformity may result in over-processing of some grains and under-processing of others.

Commercial markets determine the value of rice on the basis of the level of chalkiness and the proportion of broken grains. Chalky grains contribute to both of these properties (Fitzgerald *et al.*, 2009).

Chalky grains are incompletely filled grains and, although there is a genetic component to it, chalkiness is usually induced and is higher when plants are exposed to high temperatures during the grain-filling stage.

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Translucent grains have a higher market value and are generally preferred by consumers. The starch granules in the translucent parts of the rice grain are generally bigger and more tightly packed than the smaller, loosely packed granules found in the chalky areas of the grain (Lisle *et al.*, 2000).

Color

The color of raw milled rice is often referred to as 'general appearance'. The latter term is however more appropriate as it takes into account not only the hue, lightness and saturation, but also numerous defects that contribute to the tristimulus factors of color (Webb, 1985). Although color can be measured objectively using optical reflectance instruments, general appearance is very often determined subjectively.

Milling quality

The main objective of rice milling is to remove the bran layers and the germ with minimum breakage to the grain. Two parameters are of importance here, namely the whole grain (head rice) yield and the total milled rice yield. These parameters are affected by numerous factors including:

- Foreign material content
- Proportion of chalky and immature grains
- Proportion of damaged grains
- Variety
- Grain type
- Growing conditions
- Harvesting methods
- Control of drying conditions
- Effects of moisture adsorption and desorption.

Grain size and shape

Rice is also marketed according to grain size and shape, which are also important criteria in breeding programs. Although grain type can be classified subjectively, objective classification based mainly on the length and the length-to-width ratio are often carried out. Rice grains may be classified as short, medium, long or extra-long depending on their length. Classifications of slender, medium, bold or round are used according to the length-to-width ratio of the grain.

Cooked rice quality

The eating and cooking qualities of rice can be assessed in several ways. The amylose content (Juliano, 1971) is said to be the single most important determinant of cooked rice quality and is used — together with other characteristics such as the gel consistency (Cagampang *et al.*, 1973), gelatinization temperature (Little *et al.*, 1958) and aroma — to determine the suitability of a particular variety for a particular food preparation or consumer preference. Other parameters such as the pasting properties, water uptake capacity at 77°C (Halick and Kelly, 1959) and protein content are also important quality determinants.

Challenges

Many African laboratories are generally not equipped to carry out rice quality analyses. As a result, the above-mentioned characteristics are not being measured and rice varieties are being developed and released in most African countries solely on the basis of their performance in the field, without grain quality evaluation. Consumer preference tests are also not being carried out scientifically. Consequently, it is common to find rice varieties in many African countries that have good agronomic properties, but poor processing, eating and cooking properties. The main reasons why African rice programs do not assess these traits are that:

- The required equipment to carry out these tests is expensive to acquire, operate and maintain, and beyond the means of most national laboratories in Africa;
- There is a chronic shortage of scientists and technicians trained in rice grain quality analyses in sub-Saharan Africa;
- African laboratories are under-represented in the International Network for Quality Rice (INQR) — only two laboratories in Africa were part of the global round of amylose determinations,[1] and it is uncertain how many will take part in the impending global ring test on cooked rice texture. This makes it difficult for even the few rice-quality scientists available in the region to keep abreast with international trends in the area.

[1] Final results of the global round of amylose determinations were presented at the International Rice Congress, Hanoi, 19–20 August 2010.

INQR is a platform for scientists to compile, share and develop knowledge and materials, and to develop universal standard methods for the characterization and quantification of the traits of rice quality. Quality traits transcend the borders of germplasm classes, so members of the INQR come from rice-producing countries in tropical and sub-tropical regions. INQR collaborates with scientists who investigate issues that relate to rice quality and attempts to develop new science (new analytical methods for the major rice quality traits) into outputs that increase knowledge of rice quality and the capacity to measure it.

INQR has five taskforces:

1. Amylose
2. Measuring physical quality
3. Quantifying sensory quality
4. Aromatic compounds in rice
5. Nutritional quality.

Conclusions and future prospects

The required grain quality 'back-stopping' is not available to African rice breeding programs, and rice varieties are being developed mainly on the basis of yield and environmental tolerance traits. However, this situation can be remedied to ensure the future development of rice varieties that are high yielding, environmentally tolerant, and with good cooking and eating qualities. To do this, the following need to put in place:

- A continent-wide plan to train more rice grain-quality scientists and technicians;
- Comprehensive documentation of consumer preferences for rice quality in major rice-consuming countries in Africa;
- Breeding programs should be geared toward developing varieties that largely meet consumer preferences;
- Pooling resources to set up well-equipped sub-regional laboratories;
- Greater involvement in INQR and other relevant international networks and associations.

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