FIVE SIMPLE "IN-FIELD" METHODS FOR MEASURING SORGHUM END-USE QUALITY

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Summary

Five simple 'in-field' methods and associated standards have been developed for the determination of the end-use quality of batches of sorghum in terms of total defects, tannin grain, grain colour, grain hardness and germinative energy. A feature of the methods is that they do not require the use of specialised equipment, analytical instruments or laboratory chemicals. They should be of particular use to farmers who grow sorghum or purchase it for animal feed. The methods have been subject to two international ring trials and are currently being evaluated by the International Association for Cereal Science and Technology for provisional draft method status approval.

I. INTRODUCTION

With the aim of promoting sorghum grain trade in southern Africa, five simple “in-field” methods and associated standards were developed for the determination of end-use quality of batches of sorghum grain (Taylor, 2001). In view of the lack of scientific infrastructure in the region, a unique approach was taken. The methods were developed so that they could be understood by, be useful to and could be performed by farmers, grain traders and food processing entrepreneurs. Thus, the methods had to conform to the following strict criteria:

- The methods must be simple to perform, i.e. they should not require a skilled laboratory technician to perform them
- The methods must not require the use of specialised equipment or instruments
- Any chemicals required to perform the analyses must be readily available
- The methods should ideally be rapid
- The methods should be such that they can be performed by those in the sorghum trade, i.e. there must be no necessity to send samples to a specialists organisation to perform the analyses.

Although developed specifically for the situation in southern Africa, they and the approach used has wider applicability, in particular the methods should be useful to commercial farmers who grow sorghum and farmers who purchase the grain for animal feed.

Resulting from a survey of sorghum stakeholders (Taylor, 2001), the five grain end-use quality parameters which were deemed to be the most important were selected. These were total defects, tannin grain, grain colour, grain hardness and germinative energy. This paper will outline why each of these parameters is important, the standard methods for measuring the parameters and the developed simple “in-field” methods.

II. TOTAL DEFECTS

There are many types of defects in batches of grain. Of most concern are those that can potentially affect the safety of the end-user, such as toxic seeds, mouldy grain and non food/feed rubbish such as metal waste. Codex Alimentarius (Codex Alimentarius, 1995) and

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the United States Department of Agriculture (USDA, 1999) standards give maximum permissible levels of sorghum grain defects and some information on methodology. The International Association for Cereal Science and Technology (ICC) has a standard method with full details for the determination of Besatz (also known as dockage, defects or screenings) of wheat (ICC, 1972) which could be applied to any grain. All standard methods for quantifying defects in batches of grain are similar in principle in that they involve sieving and/or manual separation of the various fractions and then weighing to determine the mass of the fractions. Thus, the problem with such methods for the desired application is that they require specialised sieves of a specific mesh size (and often specific hole shape) and a balance weighing at the gram level to at least one decimal place of accuracy.

We have developed a method for determining the quantity of defects without the requirement for a balance or sieve. The method is outlined in Figure 1. It involves manually sorting the defects: extraneous matter, filth, blemished grains, broken kernels and other grains, and spreading them in a single layer of a sheet marked out in one square centimetres, and measuring the area. The principle of the method is that the area of defects was found to be highly significantly correlated with the mass of defects, \( R^2 = 0.933 \).

**Figure 1.** Summary of the five simple “in-field” sorghum end-use quality methods for measurement of total defects, tannin grain, grain colour, grain hardness and germinative energy.
III. TANNIN GRAIN

Some sorghum varieties (known as tannin/high-tannin sorghums or bird-resistant/proof sorghums) contain significant levels of condensed tannins (proanthocyanidins or procyanidins). The condensed tannins significantly adversely affect the feed performance of monogastric animals (Hancock, 2000), probably primarily by binding with the sorghum grain proteins, preventing them from being metabolised. The colour of sorghum grain is not indicative of whether it contains tannins, thus tannins need to be measured. The tannin content of sorghum grain can be quantified by methods such as the vanillin-HCl method developed by Burns (1971) or the International Organization for Standardization ferric ammonium citrate method (ISO, 1988). However, of more practical use is to assess the percentage of sorghum grain that is of the tannin type. The US Grain Inspection Service uses the bleach test (Waniska et al., 1992) for this purpose. The sorghum grain is heated in a solution of potassium hydroxide in bleach (sodium hypochlorite solution). The reagent dissolves away the pericarp, exposing the black tannin-containing testa layer. Tannin sorghum grains appear completely black.

We have simplified the bleach test to use an easily measured volume of commercial sodium hydroxide (caustic soda, sold in hardware stores as a drain cleaner) instead of a weight of potassium hydroxide and eliminated the requirement to heat the reagent solution. The procedure is outlined in Figure 1. The simplified test gives identical results.

IV. GRAIN COLOUR

The colour of sorghum grain ranges from almost black through to almost white. Sorghum appears coloured mainly due to anthocyanin and anthocyanidin pigments in the pericarp. Sorghum grain colour affects the colour of and preference for foods prepared from the grain. The pigments in red sorghums can also stain the gizzard of poultry.

We have developed a simple visual test whereby sorghum grain is classified either as white or coloured, regardless of signs of surface mould or purplish anthocyanic blotches. The procedure is outlined in Figure 1. The method gives complete agreement with the non-subjective Agron Color Quality Meter (Agron Inc, Sparks, USA) and Tristimulus Colorimeter (Hunter Associates, Reston, USA) instruments.

V. GRAIN HARDNESS

The hardness of grain is a measure of its resistance to milling. In sorghum, grain hardness is closely correlated with the percentage of the endosperm that is vitreous. Sorghum endosperm vitreousness affects the digestibility of the starch (Ezeogu et al., in press) and probably of the protein. Sorghum grain hardness can be quantified by measuring milling resistance using instruments such as the Tangential Abrasive Dehulling Device (TADD) (Gomez et al., 1997). It can more easily be estimated by visually assessing the ratio of vitreous to floury endosperm in grains that have been cut in half longitudinally (Rooney and Miller, 1982).

We have simplified the 5-point scale visual rating system of Rooney and Miller (1982), classifying sorghum grains into soft, medium and hard by comparison with a set of standard illustrations (Figure 1). The simplified method is highly significantly correlated with the original Rooney and Miller (1982) method, $R^2 = 0.815$. 

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VI. GERMINATIVE ENERGY

That a very high proportion of sorghum grains germinate rapidly and uniformly is of critical importance to farmers and for the end-use of malting. Germinability is a reflection of grain age and handling and storage conditions, and as such as a useful indication of grain quality even for end-uses where the grain is not germinated. There are many germination tests. For sorghum, we routinely use an adaptation of the Brewing Industry Research Foundation (BIRF) barley method (Dewar et al., 1993). The quantity of water relative to grain has been optimised for sorghum and the temperature increased to 25°C, as sorghum is a tropical grain.

We have simplified this method for “field” use as outlined in Figure 1. Newspaper circles and bottle lids and foil, instead of filter papers and petri dishes are used and the germination temperature is controlled by the use of a cooler box. Even at germination temperatures of 20°C and 30°C the simplified method is highly significantly correlated, \( R^2 = 0.899 \) and \( R^2 = 0.909 \) respectively, with our own standard method at 25°C. However, there remains one intractable problem with all germination tests, which is their long duration, up to 72 hours.

VII. CONCLUSION

The developed methods have been subjected to two international ring trials to determine their repeatability and reproducibility. The methods and associated standards have been recommended for use at a meeting of southern African sorghum stakeholders (Chemonics International, 2001). The results of the international ring trials are currently being evaluated by the ICC for provisional draft method status approval. This approach of simple “in-field” methods for determination of sorghum grain end-use quality could be extended and refined for other specific end-uses such as poultry feed. Possible additional useful quality criteria include the percentage of grains with coloured glumes and the percentage weathered (surface moulded) grains.

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REFERENCES


