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Sorghum and maize grain hardness: Their measurement and factors influencing hardness

By

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DECLARATION

I hereby declare that the thesis submitted at the University of Pretoria for the award of PhD degree is my work and has not been submitted by me for a degree at any other university or institution of higher learning.

Constance Chiremba

DEDICATION

This thesis is dedicated to my late father for his inspiration, my mother on her 60th birthday, for all her strength and encouragement and to Thandekile for the sacrifices I made to pursue my dream.

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ABSTRACT

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Sorghum and maize grain hardness is a very important criterion as grain hardness affects milling yield and product quality. There are several techniques that are used to determine grain hardness but the relationship between these techniques for distinguishing hardness in commercial sorghum and maize cultivars is not known. Moreover, the role of sorghum grain hardness with respect to malting performance is not understood, as is the role of phenolics in sorghum and maize hardness. Therefore this study investigated the relationships between sorghum and maize hardness techniques, and the influence of sorghum grain modification during malting and sorghum and maize phenolics on the hardness of these cereals.

A study to determine the relationships between techniques used to measure hardness in commercial sorghum and maize cultivars was done in terms of decortication using the Tangential Abrasive Dehulling Device (TADD) (percentage kernel removed), Near Infrared Transmittance (NIT) Milling Index (MI), test weight (TW), thousand kernel weight (TKW), kernel size (KS), stress cracking (SC) and susceptibility to breakage (SB). It was found that not all grain quality techniques were related to each other. In non-tannin sorghum, TADD hardness, TW, TKW and kernel size > 3.35 mm were correlated and can be used to select for

hardness. In maize, TADD hardness, NIT Milling Index and TW would be suitable for hardness evaluation.

The influence of malting on sorghum hardness was monitored for a period of five days following steeping. The results showed that hardness parameters including pycnometer density, floaters, TADD hardness, TKW, Single Kernel Characterisation System-Hardness Index (SKCS-HI) reduced drastically by Day 2 of malting. TADD hardness was not correlated with Diastatic Power (DP), which could be attributed to inefficient decortication due to the softening of the grain outer layers, reduced dry matter (malting loss), loss of kernel orientation and endosperm collapse during endosperm modification. However, sorghum with high DP corresponded with low values of the measured hardness parameters. Thus, in sorghum with high DP amylases accessed the starchy endosperm faster, hence the decrease in hardness. Scanning electron microscopy (SEM) confirmed that modification was influenced by amylase activity and cultivars with low amylase modified slower than those with high amylase. Hence, amylase activity was more influential in malt hardness than original grain hardness.

The phenolic acids in sorghum and maize bran and flour fractions were determined using HPLC-MS/MS. The phenolic acid content of the grain fractions was correlated with the grain hardness values. Maize bran ferulic acid content was more strongly correlated with TADD hardness but with sorghum, the relationship was weaker. Using HPLC-MS/MS, four diferulic acids were identified in sorghum and maize bran namely 8-5', 5-5', 8-*O*-4' and 8-5'-benzofuran form in quantities at least seven times less than ferulic acid. However, there was no correlation found between diferulic acids and hardness properties of both cereals.

This study shows that TADD hardness and TW are an excellent way of estimating both sorghum and maize hardness that can be applied for cultivar evaluation. The study indicates that two days of malting would be sufficient to obtain malt suitable for milling. Ferulic acid of maize and sorghum bran seems to influence grain hardness of these cereals probably through cross-linking to arabinoxylan chains in the pericarp, hence reinforcing cell wall strength.

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