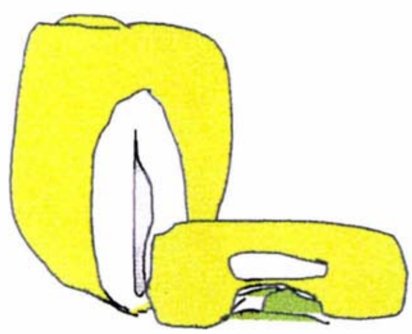
Physical changes in maize (*Zea mays* L.) grains during postharvest drying



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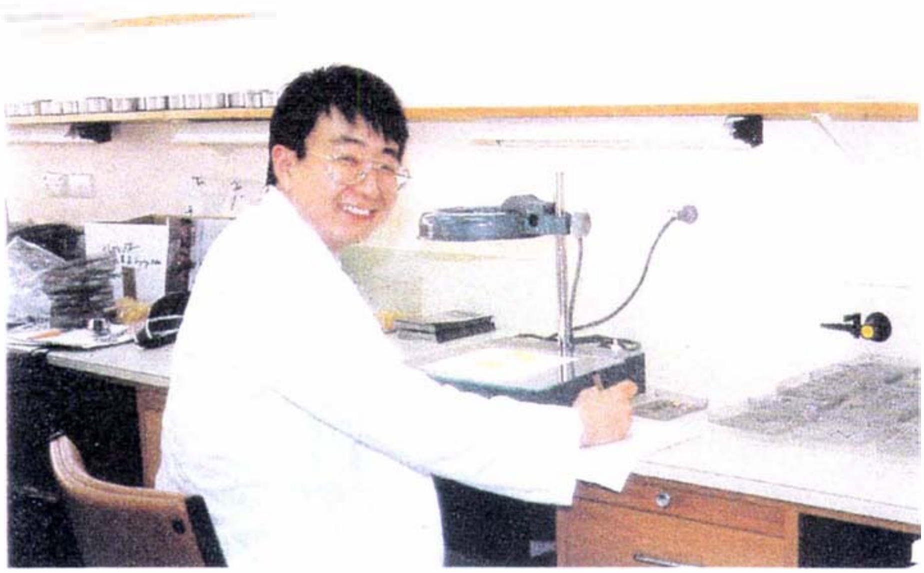

This thesis is dedicated to the four most inspirational people in my life,

my father, Kim In Goo,

my mother, Kwon Young Wha,

grandmother, Jung Bong Hee,

and my lovely wife, Kim Hyun Ok and

to the unforgettable memories in

New Zealand...

ABSTRACT

Stress cracking due to high temperature drying has been of concern to the maize industry because it can lead to increases in broken grain and fine material during subsequent handling. In this study, several factors affecting physical characteristics of maize grain, particularly those related to stress cracking, were investigated.

In the first year (1995-1996), the effects of several preharvest factors; hybrid, nitrogen, harvest grain moisture content, and postharvest drying factors including drying temperature and relative cooling rate on physical attributes and stress cracking in grain were investigated. Grain hardness (hard to soft endosperm ratio (H/S ratio)) was significantly affected by the interaction between hybrid and nitrogen. The effect of drying temperature and harvest moisture on drying time was dominant, while drying rate was significantly affected by hybrid and drying temperature. The effect of cooling rate on stress cracking and stress crack index (SCI) stood out among the main effects. At the lowest cooling rate of 0.23 (°C/°C/min.)•10^{-2}, checked stress cracking (checking) was minimal, and SCI was less than 100. However, at higher cooling rates from 0.55 to 1.11 (°C/°C/min.)•10^{-2}, grains had more than 25% multiple stress cracking, regardless of the levels of hybrid, nitrogen, harvest moisture and drying temperature. The predicted SCI for the three hybrids reached a maximum around at 0.75 (°C/°C/min.)•10^{-2} cooling rate, irrespective of levels of nitrogen and drying temperature.

In the second experiment (1996-1997), the effects of grain hardness and morphological factors (grain size and shape) at a single grain drying rate and the development stress cracking over time were investigated. The re-parameterized Morgan-Mercer-Flodin (MMF) model successfully predicted the increasing rate (κ) and the maximum value (α) of percentage checking in various sizes, shapes and hardness of grains time after drying. From the data analysis, the maximum value of checking (α) showed a significant correlation with grain length (r = -0.707), thickness (r = 0.620), roundness (r = 0.703) and the shortest diffusion pathway (SDP; r = 0.627). While, the increasing rate (κ) of percentage checking with time after drying was significantly correlated with

grain bulk density (r = -0.564), hardness ratio (r = -0.611) and drying rate (r = 0.551), and to a lesser extent (r > 0.35), with the grain size parameters including hundred-grain weight, grain length, and width. Based on this result, it was suggested that removing small and rounded grains could reduce checked stress cracking by up to 40 to 50% in some dent maize hybrids. In addition, the standardized multiple regression for single grain drying rate according to H/S ratio and grain weight accounted for from 65 to 74% of the variation. Tempering grain at high temperatures reduced stress-cracked grains significantly. However, the effect of tempering on stress cracking in the hard grain hybrid was small.

In the 1997-1998 experiment, a breakage tester (HT-I drop tester) was developed and single grain breakage at various grain temperatures and times after drying was determined. Both hard and soft maize hybrids had minimal breakage at high grain temperatures (78 to 110°C), while decreasing grain temperature increased breakage exponentially. This indicated that grain temperature should be considered as a co-factor for measuring grain breakage. After drying at both 60°C and 120°C, the percentage breakage measured at ambient temperature increased rapidly during cooling in air at an ambient temperature of 20°C and a relative humidity around 65-70%. Breakage reached a maximum after about 10 minutes from the start of cooling. A Mitscherlich function was used to describe the chronological development of percent grain breakage and the analysis of the function parameters for the extent (maximum) and rate of breakage indicated that there was a significant interaction between hybrid and drying temperature for the development of grain breakage after drying.

In conclusion, the MMF and Mitscherlich models described stress cracking and grain breakage during drying and cooling of maize grain. These studies provide valuable information to grain industries to assist with minimizing grain damage during drying.

Key words: maize, quality, stress cracking, breakage susceptibility, viscoelastic, hardness, postharvest drying, cooling, tempering, nitrogen, hybrid, harvest moisture, size and shape, breakage tester.

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