PERFORMANCE EVALUATION
OF A PROTOTYPE FLAT-BED GRAIN DRYER

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ABSTRACT

The performance of a new prototype flat-bed grain dryer designed for experimental research was evaluated using yellow dent maize grain of two hybrids ("Clint" and "Raissa" which are hard and soft, respectively) in three separate experiments. In experiment I, grain samples at three initial moisture contents (approx. 20, 25 and 30 % w.b.) were dried at three air temperatures (58, 80 and 110 °C). Dryer performance parameters such as drying time, drying rate, capacity, efficiencies and energy consumption were determined and the dried grain quality attributes were also evaluated. A thin layer drying model for predicting dried grain moisture ratio was proposed. In experiments II and III, grain samples were dried at 80 °C air temperature from 25 % to 14.5 % moisture content, cooled or tempered before assessment of grain quality attributes. Overall, the dryer performance was good in terms of its operation and effects on quality of dried grain. Both dryer operational performance and dried grain physico-mechanical properties were affected by drying air temperature, grain initial moisture content, and the post-drying treatments. Low initial grain moisture content and high drying temperatures increased dryer capacity and reduced total energy consumption for drying. However, both high drying air temperature and high initial grain moisture content increased the incidence of grain damage. Slow cooling and/or tempering of the dried grain increased grain bulk density and reduced breakage susceptibility, especially when cooled or tempered in an airtight and well insulated container. However, these two post-drying treatments did not affect grain hardness significantly. Finally, a conceptual model for evaluating and optimising the performance of mechanical grain dryer is proposed.

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INTRODUCTION

1.1 Introduction

Knowledge of the production and utilisation of cereal grains is fundamental to solving the food supply problem facing the majority of the world's population. Grains are not only important direct sources of food for humans, but also make a substantial contribution to the diet, indirectly as fodder, for farm livestock producing meat, milk, and eggs (Lorenz and Kulp, 1991). In most countries grains are among the most important staple foods but they are produced on a seasonal basis, and in many places there is only one harvest a year. Grain storage is essential for marketing and to ensure availability for late consumption for periods varying from one month up to more than a year (Picard and Proctor, 1994).

Since grains are often harvested at moisture contents that are too high for safe storage, immediate and effective treatment of the freshly harvested grains is essential to prevent quality deterioration (Brooker et al., 1992). One of the most affective treatments is drying. It is the most practised grain preservation method that enables grains to attain moisture content sufficiently low to minimise infestation by insects and micro-organisms, such as bacteria and fungi, and to prevent unwanted germination (Hill, 1997). Grain drying has been used since early civilisation to preserve it for food (Hoseney, 1994).

Traditionally, grain crops are harvested during a dry period and simple drying methods such as sun drying are adequate. However, maturity of the crop does not always coincide with a suitably dry period. Furthermore, the introduction of high yielding varieties and hybrids, irrigation, improved farming practices, and multi-cropping have led to the need for alternative drying practices to cope with the increased production. Responding to these, scientific research has been remarkably successful in increasing the quantity and quality of grain through the application of improved drying and storage technologies. Various studies have focused on improving grain quality by introducing new and suitable dryers for different purposes. Nowadays, mechanical or artificial dryers, long used in developed countries, are finding increased application as farming and grain handling systems improve in many developing countries (Trim and Robinson, 1994).

The need to dry grain artificially arises from the basic need to provide uniformly good quality grain which will facilitate its long terms storage and processing. Artificial grain drying assists this objective by minimising weather effects on the harvest (Bakker-Arkema et al., 1995). Annual postharvest loss of grains is estimated at 10 % and therefore moisture control, primarily by drying, provides an opportunity to prevent losses which occur during harvesting, handling and storing (Hall, 1980).

The performance of grain dryers and good understanding of the effects of drying on grain quality are very important to satisfy the need of grain producers, grain traders, grain processors and grain users since it is generally agreed that improper drying is the major cause of high drying cost and grain deterioration. Poor or defective drying equipment or incorrect drying procedures may result in high costs, low capacity and efficiencies, very fast drying rate, incomplete drying, high milling losses, poor quality or reduced germination capacity of the dried seed (ESCAP, 1995). Nellist and Bruce (1992) stated that the main reasons for testing grain dryers are: (a) to aid the development of a prototype, (b) to confirm the specified performance and (c) to provide information for marketing and operator guidance. Of particular concern is the increase in dryer capacity and drying rate by using drying air temperatures higher than those recommended which can lead to a reduction in grain quality (Radajewski et al., 1988). Hardacre (1997) observed that aggressive commercial drying could result in fine materials (measured by mechanical impact test) in excess of 40 % of the grains but careful commercial drying results in grains with the fine less than 10 % regardless of the grain hardness.

Prototype dryers are often used in grain breeding research to evaluate the quality of grain after drying, thereby assisting in assessing the economic feasibility of new cultivars and hybrids. Recently, a new prototype grain dryer was designed and constructed by the maize breeding team at the New Zealand Crop and Food Research Ltd., Palmerston North, for experimental purposes.

The aim of this study was to investigate the potential of the new grain dryer for achieving high capacity, efficiencies, and drying rates and low costs with minimum reduction in dried grain quality.

1.2 Research Objectives

The specific objectives of this research study were to evaluate the performance of a new prototype flat-bed grain dryer by:

- Determining the effects of initial grain moisture content and drying air temperature on drying time, drying rate, dryer capacity, drying efficiencies and energy consumption;

- Quantifying the effects of grain moisture content and air temperature on grain quality attributes; and

- Quantifying the effects of post-drying treatments (cooling and tempering) on quality attributes of dried grain.