Journal of the Saudi Society of Agricultural Sciences (2012) **11**, 123–128

King Saud University

Journal of the Saudi Society of Agricultural Sciences

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FULL LENGTH ARTICLE

Effect of germination on antinutritional factors, total, and extractable minerals of high and low phytate corn (*Zea mays* L.) genotypes

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Received 3 January 2012; accepted 19 February 2012
Available online 3 March 2012

KEYWORDS

Corn;
Genotype;
Antinutritional factors;
Minerals;
HCl-extractability;
Germination

Abstract Two corn genotypes, Var-113 (high phytate) and TL-98B-6225-9×TL617 (low phytate) were germinated for 6 days. The germinated seeds were dried and milled. Phytic acid, polyphenols, and hydrochloric acid (HCl) extractable minerals were determined at intervals of two days of germination. Phytic acid decreased significantly ($P \leqslant 0.05$) with a concomitant increase in HCl extractable minerals, while polyphenol contents increased significantly ($P \leqslant 0.05$) with an increase in germination time. However, the major mineral content was initially decreased and then increased while that of trace minerals was increased with germination time. After 6 days of germination, the high phytate sample (Var-113) exhibited higher extractable calcium compared to the other genotype, whereas the low phytate sample (TL-98B-6225-9×TL617) showed higher extractable phosphorus. Iron extractability was higher for the low phytate samples, while that of magnesium was higher for the high phytate sample. High correlation between lower phytate and higher extractable minerals was noted as a function of longer germination time. Nevertheless, no correlation was observed between polyphenol content and mineral extractability level.

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Peer review under responsibility of King Saud University.
doi:10.1016/j.jssas.2012.02.002

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1. Introduction

The demand for cereals as food and feed is increasing due to population explosion in developing countries and shortage of main foods. It is well established that the majority of the people in the developing countries depend mainly on cereal grains as their staple food due to limited income and the high prices of animal foods. Like other cereals, the nutritive value of corn is inadequate due to its deficiency in the essential amino acids of lysine and tryptophan (Fageer et al., 2004). A comparison of

available data for wheat, corn and rice puts corn as the second most important cereal grain after wheat and before rice in terms of production yield (FAO, 1992). The increment in maize production resulted from additional field area planted, genetic improvement and more efficient technological field practices as well as introduction of new and more highly productive varieties. The corn produced in the developing countries is consumed for human nutrition while in the developed ones it is mainly used for industrial use and animal feed purposes (FAO, 1992). Because of its economic importance, genetic improvement of corn has played a key role in the development of genotypes with high protein quantity and quality. This could be achieved through either a reduction in the zein storage protein fraction or an increase in the proportion of other protein fractions or a combination of the two (Or et al., 1993). Because of the great importance of maize as a basic staple food for large population groups, particularly in developing countries, and its low nutritional value, mainly with respect to protein, many efforts have been made to improve the biological utilization of its nutrients. In this regard, three approaches have been introduced: genetic manipulation, processing and fortification.

Phytate and polyphenols have been considered as antinutritional factors because they interact with food constituents such as minerals and make them unavailable (Abd El Rahaman et al., 2007; Idris et al., 2006). Sharma and Kapoor (1997) reported that millet contained some antinutrients (phytate and polyphenols) that affect nutrient absorption by the human body. Reductions of such antinutritional factors by processing methods such as soaking, sprouting, cooking, malting and fermentation have long been documented by many researchers (El Maki et al., 1999; Idris et al., 2006; Lewu et al., 2010; Obizoba and Atii, 1994; Osman, 2011; Vadivel et al., 2011) but such information still needs more investigation. It has been reported that germination of various pearl millet cultivars significantly increased the HCl-extractable parts of both major and trace minerals, and also significantly reduced ($P \leqslant 0.01$) the phytic acid and polyphenol contents of the cultivars (Abd El Rahaman et al., 2007). In Sudan, the research into the mineral content and extractability in corn as an important food has not been fully documented. Therefore, in this study we would like to evaluate the effect of germination on the antinutritional factors content and HCl-extractable minerals of high and low phytate corn genotypes.

2. Materials and methods

2.1. Materials

Two corn genotypes Var-113 (high phytate) and TL98B-6225-9×TL617 (low phytate) were obtained from the Department of Agronomy, University of Khartoum. The samples were carefully cleaned to be free from foreign materials and part of the grains was ground to pass through a 0.4-mm screen and kept in polyethylene bags at 4 °C for further analysis. All chemicals used in this study were of reagent grade.

2.2. Sample preparation

The genotype grains were cleaned manually to remove broken seeds, dust and other extraneous materials. The cleaned grains were steeped thrice in water for 12 h with 1 h air rest after 6 h of steeping. For each air rest, the steeping water was changed. After steeping, the grains were sterilized by soaking in 1% sodium hypochlorite for 20 min before it was drained prior to germination. The steeped grains were spread on wet jute bags and covered with a moist cotton cloth and left to sprout at room temperature (32–38 °C) for 2, 4 and 6 days as described by Obizoba and Atii (1994). After germination, the seeds were dried in a Gallenkamp oven (BS model OV-160; Manchester, UK) at 50 °C for 24 h. Rootlets and shoots of the grains were separated from the kernels by rubbing the germinated grain in a 0.6 mm sieve (Endecotts Ltd., London, UK). The unmalted and malted grains were separately milled into fine flour with a hammer mill (Gibbons Electric, Essex, UK) to pass through a 0.4 mm sieve for determination of phytic acid, polyphenols and HCl extractability of minerals.

2.3. Phytic acid determination

Phytic acid content of the samples was determined using the method described by Wheeler and Ferrel (1971) using 2.0 g dried sample. A standard curve was prepared expressing the results as $Fe(NO_3)_3$ equivalent. Phytate phosphorus was calculated from the standard curve assuming a 4:6 iron to phosphorus molar ratio.

2.4. Polyphenol determination

Total polyphenols were determined according to the Prussian blue spectrophotometric method (Price and Bulter, 1977) with a minor modification. Sixty milligrams of ground sample was shaken manually for 1 min in 3.0 ml methanol. The mixture was filtered (Whatman No. 1). The filtrate was mixed with 50 ml distilled water and analyzed within an hour. About 3.0 ml of 0.1 M $FeCl_3$ in 0.1 M HCl was added to 1.0 ml filtrate, followed immediately by timed addition of 3.0 ml freshly prepared $K_3Fe(CN)_6$. The absorbance was monitored on a spectrophotometer (Pye Unicam SP6-550 UV, London, UK) at 720 nm after 10 min from the addition of 3.0 ml of 0.1 M $FeCl_3$ and 3.0 ml of 0.008 M $K_3Fe(CN)_6$. A standard curve was obtained, expressing the result as tannic acid equivalents; that is, the amount of tannic acid (mg/100 g) that gives a color intensity equivalent to that given by polyphenols after correction by blank sample.

2.5. Mineral composition

Minerals were determined by the dry ashing method described by Chapman and Pratt (1982). About 2.0 g of sample was acid digested with diacid mixture (HNO_3:$HClO_4$, 5:1, v/v) in a digestion chamber. The digested samples were dissolved in double-distilled water and filtered (Whatman No. 41). The filtrate was made to 50 ml with double-distilled water and was used for determination of total minerals. Calcium was determined by the titration method described by Chapman and Pratt (1961). Briefly, to 2 ml of the extracted sample in a 50 ml conical flask, 10 ml of distilled water was added. Then drops of 4 N NaOH were added to a small amount of meroxide indicator that gave a pink color. The contents of the flask were titrated with 0.01 N EDTA until a violet color was obtained which indicating the end point. The titration readings were used to calculate the calcium content. Phosphorus was determined by vanadate–molybdate method (Chapman and Pratt, 1982). Five millilitres of the aliquot extracted above

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