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EFFECT OF GERMINATION ON THE CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF MAIZE GRAIN

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ABSTRACT

An investigation was conducted to study the effect of germination on nutrients and vitamin content of yellow maize. Results indicated that germination significantly ($p \leq 0.05$) increased the protein and ash content from 10.34% and 2.02 % in raw maize to 11.78% and 2.10 % in the germinated maize flour samples. The niacin content also increased from 1.85 to 3.2 mg/kg. However fat was found to decrease from 4.02 % to 3.13 % after germination. Carbohydrates and fiber content were also decreased from 80.67% and 2.12 % to 79.58 % and 1.91 % in germinated maize flour. Energy content decreased from $400.22 \pm 12.33$and 393.61 ± 9.94 after germination. The present investigation revealed that the germination significantly enhanced the protein, ash and niacin content of maize which is found in limited amounts and in biologically unavailable form in most maize varieties.

INTRODUCTION

Maize (*Zea mays*) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. In India, maize is the third most important food crops after rice and wheat (Singh *et al.,* 2014). Between now and 2050, the demand for maize in the developing world will double and by 2025 maize will have become the crop with the greatest production globally (Kadam *et al.*, 2012). Maize is a multipurpose crop, providing food and fuel for human being and feed for animals (poultry and livestock). It also has wide industrial applications and nearly two hundred different kinds of products can be processed or obtained from maize (Nnam 2000).

Maize constitutes an important source of carbohydrates, vitamin B, and minerals (Ocheme *et al.,* 2008). The protein of the maize has low biological value as compared to whole wheat and rice. Niacin one of the vitamins essential for health occurs in bound form (Niacytin) in maize and is biologically unavailable (Otitoju *et al.*, 2009). Niacin deficiency can cause Pellagra in populations that are dependent on maize (Mbata *et al.,* 2009). It is essential to develop avenues for improving the protein quality and niacin content of maize and maize products intended for human consumption. Germination can increase the biological value of protein content, dietary fiber, reduce tannin and phytic acid content and increase mineral bioavailability (Ghavidel and Prakash, 2007).

Germination unlocks many nutrients which are in bound forms, increases nutrient bio-availability, energy density and acceptability (El-Adawy *et al.,* 2004). During germination of seeds, α-amylase and protease degrade starch granules and reserve proteins, respectively thereby reducing the dietary bulk and improving the digestibility of starch and protein. Lipases are hydrolyzing triacylglycerols into fatty acids and glycerol (Thakare *et al.*, 2014). Therefore, there is a need to develop a standard protocol for germination of maize to increase nutrient availability. In this view, the current study was carried out to study effects of germination on the nutrients and vitamin content of yellow maize.

MATERIALS AND METHODS

An investigation on effect of germination on nutrients and vitamin content of yellow maize was carried out in the Department of Post Harvest Technology, Sher-e-kashmir University of Agriculture Sciences and Technology, Jammu during the year 2011-2012. Yellow maize was purchased from local market, hand sorted to remove splits wrinkled seeds and foreign materials and washed thoroughly with running water. Germinated maize flour was prepared by using the method described by Gernah *et al.*, (2012). Maize grains were washed in 5% (w/v) sodium chloride (NaCl) solution to disinfect the grains, and soaked in tap water at room temperature (30 ± 5ºC) using a ratio of 1:3 (w/v grain: water). The steep water was changed every 4 hour for a total steeping time of 12 hour and the grains were put under wet muslin cloth and allowed to germinate at room temperature (30 ± 5ºC) for 72 hour, while spraying with water at intervals of 12 hour. The grains were removed after 72 hour and dried in oven at 80ºC ±ºC to constant weight. The dried seeds were milled into flour using a bench top hammer mill and stored in aluminum pouches for analysis.

Determination of nutrients and vitamin contents of Raw maize and germinated maize flour

Moisture content (AOAC, 2000)

Weighed 10 gm sample in triplicate were dried in hot air oven at 130ºC $\pm$ 1ºC in pre-weighed dishes till constant weight. The dish with dried sample was transferred to desiccators, cooled and weighed. Moisture content in percent was calculated from loss in weight.

$$\text{Per cent moisture} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \text{X } 100$$

Crude protein (AOAC, 1995)

Crude protein was estimated by using micro-kjeldahl method, using the factor 6.25 for converting nitrogen content into crude protein. Weighed sample (2.0 g) was digested for 2 hours with 25 ml concentrated sulphuric acid and 2 gm digestion mixture (2.5 g SeO2, 100g K2SO4 ad 20 gm CuSo4) in kjeldahl digestion flask. The contents were cooled and volume was made up to 100 ml. Ten milliliters of this aliquot was distilled with excess of 30 % sodium hydroxide and liberated ammonia was collected quantitatively in 2 per cent boric acid solution containing a few drops of mixed (methyl red and bromocresol green) indicator. The boric acid solution was titrated against standardized 0.01 NHCL and protein content was calculated using the equation given below:

$$\text{Per cent Nitrogen} = \frac{\text{Titre value x Normality of HCL x volume made up of digest X 100}}{\text{Aliquot taken (g) x weight of sample (g) X 1000}} \text{x } 100$$

Protein, % = Nitrogen % X 6.25

Crude Ash (AOAC, 1995)

Five gm sample was weighed and transferred in pre-weighed crucible and charred over the heater to make it smoke free. The crucible along with the sample was ignited at 600ºC for 3 hours in a muffle furnace. When muffle furnace was slightly cooled, the crucible with ash was taken out, kept it desiccators to cool down, and weighed to a constant weight. The difference between the weight of silica crucible as empty and with ash was the amount of total ash. The per cent ash was calculated from the following formula.

$$\text{Per cent ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \text{X } 100$$

Crude fat (AOAC, 2000)

Five gm of dried sample was extracted with petroleum ether in soxhlet extraction for 6 hour. The ether extract was filtered in pre-weighed beakers, petroleum ether was evaporated completely from the beakers and the increase in weight of beaker was evaporated completely from the beakers and the increase in weight of beaker represented the fat content.

Weight of the sample = W (g)

Weight of the empty beaker = W_1 (g)

Weight of the empty beaker + fat content (ether extract) = W_2 (g)

$$\text{Per cent fat content} = \frac{\text{Amount of the ether extract (g)}}{\text{Weight of sample (g)}} \text{X } 100$$

$$= \frac{W_2\text{-}W_1}{W} \text{X}100$$

Crude fiber (AOAC, 2012)

Two gram fat free dried sample was transferred to 600 ml beaker and 200 mL of 1.25 per cent H_2SO_4 was added Beaker was placed on digestion apparatus with pre-adjusted hot plate and boiled for 30 minutes. Filter the contents through a filter paper. Washed the residue with hot distilled water till it was free from acid. Transferred the material to the same beaker with 200mL of 1.25 percent sodium hydroxide. Digest the contents for half an hour, filter and wash free of alkali using hot distilled water. The residue was transferred to crucibles, weighed, dried in an oven overnight at 105ºC and then placed in the muffle-furnace at 600ºC for 3 hours. The loss in weight after ignition represents the crude fiber in the sample.

$$\text{Per cent crude fibre} = \frac{\text{Loss in Weight}}{\text{Weight of sample}} \text{X}100$$

Carbohydrates (AOAC, 2012)

Amount of carbohydrates was calculated from the sum of moisture, crude protein, crude fat, ash and crude fiber and lastly subtracting it from 100.

Energy content (Atwater and Bryant 1900)

Atwater general factor system was used to calculate energy using single factor for each of the energy-yielding substrates (protein, fat, carbohydrate). The energy values are 17 kJ/g (4.0 kcal/g) for protein, 37 kJ/g (9.0 kcal/g) for fat and 17 kJ/g (4.0 kcal/g) for carbohydrates.

Data analysis

Each experiment was independently replicated at least three times. All data were analyzed using one way ANOVA by means of statistical computer software, (SPSS). Differences between means were compared using the Turkeys method at $p \leq 0.05$.

RESULTS AND DISCUSSION

The present study revealed that upon germination protein ash and niacin increased significantly whereas carbohydrate, fiber, fat and energy content decreased after germination. The moisture content between the raw and germinated maize flour

Table 1: Proximate composition of raw maize flour and germinated maize flour

Parameters	Raw maize flour	Germinated maize flour
Moisture (%)	13.96 $\pm$0.06	9.05 $\pm$0.05
Crude fat (%)	4.02 $\pm$ 0.8	3.13 $\pm$0.9
Crude fiber (%)	2.12$\pm$0.7	1.91 $\pm$0.8
Ash (%)	2.02$\pm$0.67	2.10$\pm$0.7
Carbohydrates (%)	80.67$\pm$ 2.89	79.58$\pm$3.52
Energy (Kcal)	400.22$\pm$12.33	393.61$\pm$9.94

Values are expressed as mean $\pm$ standard deviation (n = 3). Mean values within same row are significantly different ($p < 0.05$).

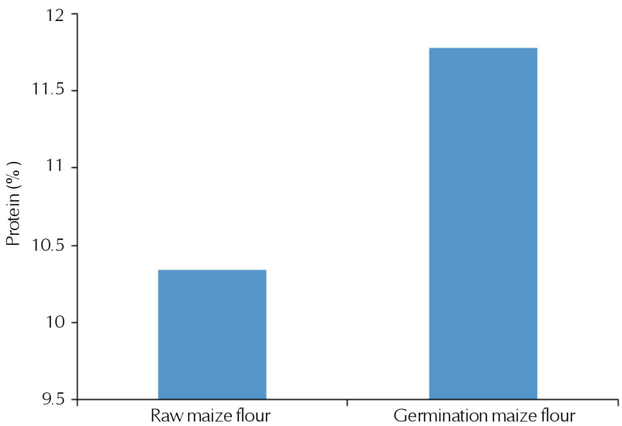

Figure 1: Effect of germination on crude protein content (%) of maize

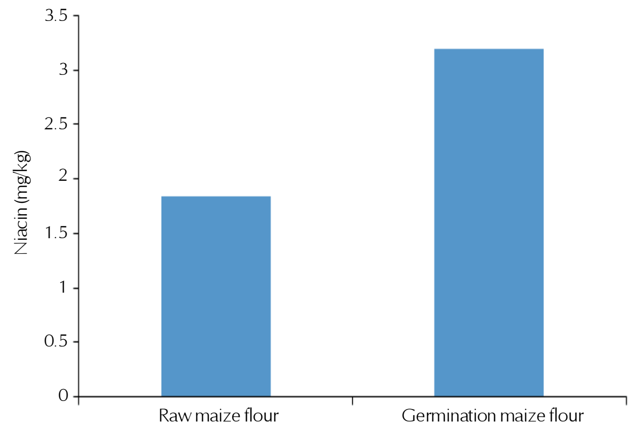

Figure 2: Effect of germination on niacin content (mg/kg) of maize

was different as depicted from (Table 1). There were significant (P d" 0.05) differences in the moisture content of raw maize and germinated maize samples. The moisture content for raw maize grains were 13.96 % and 9.05 % for germinated maize flour respectively. The moisture content of the ungerminated flour samples was significantly higher than that of the germinated maize flour due to the exposure of germinated grains to high temperatures (80 °C) during drying after germination. There was significant increase in protein content after germination. The protein content was 10.34% in raw maize and 11.78% in the germinated maize flour samples (Fig 1). The increase in the protein content is due to increased activities of enzyme protease during germination or may be due to the fact that some amino acids are produced in excess of the requirement during protein synthesis and these tend to accumulate in the free amino acid pool. The increase in the protein during germination may also be due to mobilization of storage nitrogen producing the nutritionally high quality proteins which the young plant needs for its development. These observations are supported by earlier observations that germination increases the protein content of germinated seeds (Uwaegbute *et al.,* 2012).

Parallel to protein content, a progressive increase was also observed in ash content. The ash content was 2.02 % and 2.10 % in raw maize and germinated maize flour (Table 1). The increase is due to increased activity of the enzyme phytase, this enzyme hydrolyses the bond between the protein-enzyme mineral to free more minerals like phosphorous. Significant increase was also observed in Niacin content. Germination increased the niacin content from 1.85 to 3.2 mg/kg (Fig 2). These results showed that germination can significantly increase the niacin content of maize which is in bound form in raw maize.

However a decrease in fat content was observed after germination. The fat content was 4.02 % and 3.13 % in raw maize and germinated maize flour (Table 1). The fat decreased due to increased activities of the lipolytic activity during germination which hydrolyses fat to fatty acids and glycerol. The carbohydrates and fiber content was 80.67%, 2.12 % and 79.58 %, 1.91 % in raw maize and germinated maize flour (Table 1). The decrease in carbohydrate content and crude fiber may be due to increase in the alpha-amylase activity that breaks down complex carbohydrates to simpler and more adsorbable sugars which are utilized by the growing seedlings during the early stages of germination. The energy values of the raw maize flour samples were 400.22 ± 12.33 in raw maize and 393.61 ± 9.94 for germinated flour samples (Table 1) respectively. The energy values of germinated sample were lower than those of raw maize flour samples because germination which is the process of soaking and steeping dry seeds in water, involves chemical changes due to the hydrolysis by the amylolytic enzymes α and β-amylases,of complex macromolecules such as starch into low-molecular-weight and more digestible, molecules. In addition, degradation and oxidation of starch observed during respiration provide energy for the increased metabolic functions in the germinated seeds. That may explain the decrease in energy value observed in maize after germination.

In the present study, germination significantly increased the protein, ash and niacin content of maize. In summary, germination could play a vital role in improving the nutritional content of germinated maize products which constitutes a major portion of the diet in poor and rural communities and is sometimes used as a weaning food for children.

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