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Effect of germination and fermentation on nutrients in maize flour

Martin Patrick Ongol[1*], Eugène Niyonzima[1,2], Innocent Gisanura[1], Hilda Vasanthakaalam[1]

[1]Food Processing Laboratory, Department of Food Science and Technology, University of Rwanda,

Avenue de l'armée, P.O. Box. 3900 Kigali, Rwanda

[2]University of Liège – Gembloux Agro Bio Tech, Laboratory of Quality and Safety of Food Products,

Passage des Déportés, 2 – 5030, Gembloux, Belgium

[*]Corresponding author: mp.ongol@hotmail.com; marongol@hotmail.com

ABSTRACT

Germination and fermentation have been reported to improve bioavailability of nutrients and vitamin content of cereal-based food products. The objective of this study was to evaluate the effects germination, fermentation and germination combined with fermentation on the protein, fat, fibre, moisture and niacin content of maize varieties ZM 607 and Tamira Pool A9. Germination and fermentation significantly ($P \leq 0.05$) increased the protein and niacin content of both maize varieties. The niacin content of ZM 607 increased from 1.2 to 11.5 mg/kg while that of Tamira Pool A9 increased from 1.2 mg/kg after germination and fermentation. The fat and fibre contents of both ZM 607 and Tamira Pool decreased after fermentation and germination. The results obtained in this study showed that germination and fermentation could be used to significantly enhance the protein and niacin content of maize which is often found in limited amounts and in biologically unavailable form in most maize varieties.

Key words: Maize; Germination; Fermentation; Niacin

INTRODUCTION

Maize (*Zea mays*) has a major influence on the global use of land, human diet and the quality of human lives. It has a high energy value and is used for human food and animal feed (Brockway, 2001). It also has wide industrial applications and nearly two hundred different kinds of products can be processed or obtained from maize. In many developing countries maize is a staple food, and many African communities are shifting from production of sorghum and millet to maize due to reduced labour requirements for maize production. Many aid agencies, government institutions on stringent budgets, non-governmental organisations often supply maize to drought and famine stricken areas. Despite its long history of cultivation, maize has relatively poor nutritional characteristics. It is well documented that maize contains protein with low biological value (54%) and a net protein utilization of 49% which is quite less compared to whole wheat and rice (Okoruwa & Kling, 1996; Brockway, 2001; Antia, 2000). Maize has negligible amounts of niacin, one of the B vitamins essential for health (Brockway, 2001). Moreover, the niacin in maize occurs in bound (niacytin) which is biologically unavailable. Although tryptophan intake can also substitute for lack of niacin in the body, the tryptophan content in maize exists at a very low level that cannot lead to sufficient synthesis of niacin in the body. Consequently, diets that rely heavily on maize may be deficient in certain amino acids such as lysine and tryptophan and vitamins. Pellagra, the niacin deficiency disease is common in populations that are dependent on maize (Okoruwa & Kling, 1996). The primary cause of pellagra is a lack of niacin, tryptophan, or both, and this condition classically manifests as a triad of dermatitis, diarrhea, and dementia that can lead to death (Seal *et al.*, 2007). The prevalence of pellagra may be countered by eating foods that complement the protein and vitamins present in maize to provide a well-balanced diet (Okoruwa & Kling, 1996). It is also essential to develop avenues for improving the protein quality and niacin content of maize and maize products intended for human consumption.

In Africa, where maize is mostly used for human consumption, dietary preferences, processing and mode of preparation affect the contribution of maize in human nutrition. Germination and fermentation of cereals is an affordable and widely practiced processing technique that has been practiced in Africa for generations. Germination unlocks many nutrients which are in bound forms, increases nutrient bio-availability, energy density and acceptability (Mtebe *et al.*, 1991). Fermentation of food has been practiced for improving the flavour, texture and

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palatability of maize based diets where maize flour serves as an important base to manufacture different fermented products (FAO, 1992). It is also documented that fermentation enriches cereal food in protein by removal of part of the carbohydrates, helps to reduce energy required for cooking and to make safe products (Nyako & Danso, 1991; Chevan & Kadam, 1989; Steinkraus, 1978). Therefore, the purpose of this study was to investigate the effects of germination, fermentation and the combined effects of germination and fermentation on the protein, fibre, fat, moisture and niacin content of maize varieties Zm 607 and Tamira Pool A9 varieties that are widely cultivated in Rwanda.

MATERIALS AND METHODS

Sample preparation

Two maize varieties (Zm 607 and Tamira Pool A9) that had a great demand among the farmers were selected from National Seed Centre of Rubirizi in Kicukiro District (Rwanda). Maize grains were suitably tempered for 48 h in water to initiate germination. The soaked seeds were subjected to 72 h of germination. The germinated seeds were dried using a locally designed hot air dryer and milled. The obtained germinated flour (500 g) was made into dough with by addition of water and subjected to natural fermentation for a period of 8 h at ambient temperature. The dough was then subjected to sun drying and milled to obtain fine flour. Flour samples were obtained from untreated maize (that served as control), germinated maize, fermented maize and also maize subjected to both germination and fermentation.

Flour analysis

Flour moisture, protein, fat and fat content were determined using AOAC methods (2005). Crude fibre content was determined as described by Osborne & Voogt, 1978. Niacin was determined by HPLC (Shimadzu, Kyoto, Japan) system consisting of a column oven (model SCL-10AV), system controller, a UV-visible diode array detector (model SPD-M10-AVP); Shimadzu software was used to calculate the peak areas. The sample (30 UI) was injected into the HPLC with a syringe (Hamilton, Reno; NV, USA). The HPLC column used was a reserved phase discovery C18 (150 mm x 4.6 mm, 5 Um) from Supelco (Bellefonte, PA, USA). Flour analysis was done in duplicate and mean values calculated.

Data analysis

Each experiment was independently replicated at least two 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 DISCUSSIONS

Moisture content

The moisture content between the selected maize varieties was different as depicted from (Table 1). There were no significant ($P \leq 0.05$) differences in the moisture content of control, germinated, fermented and germinated and fermented maize samples. The total moisture was 9.6% in Zm 607 and 11% in Tamira Pool A9. Meanwhile the dry matter content in ZM 607 was found to be 90.4% for control and 89% after germination respectively. After 72 h of germination the moisture content increased to 11% and 12% in Zm 607 and Tamira Pool A9 respectively. The insignificant increase in moisture content of the maize samples that were fermented and fermented and germinated maize samples could be due imbibitions of water during the tempering process.

The moisture content of the maize samples used in this study was within the range of 5.6 to 14% reported by FAO (1992). In a study conducted by Mtebe *et al.*, (1991) maize grown in Tanzania (*Zea mays* Staha) had a moisture content of 12.13% and when subjected to 72 h germination the moisture content increased to 12.54% (0.41% increase) which is slightly lower than the 1 to 1.4% increase reported in this study. The slight differences in the moisture content could be attributed to differences in the varieties used in the two studies.

In studies assessing the effect of germination and fermentation on the nutritional content of maize it is important to determine the moisture content since higher moisture content may initiate biochemical changes which in turn may affect the nutritional composition of the maize samples leading to inaccurate results and conclusions.

Protein content

Protein content was 5% and 8% in the control samples of Zm 607 and Tamira Pool varieties respectively (Fig 1a and 1b). In ZM 607 germination did not result into significant ($P \geq 0.05$) increase in protein content while in Tamira Pool A9 germination resulted into a significant ($P \leq 0.05$) increase in protein content. In a study conducted by Mtebe *et al.*, (1991) on maize grown in Tanzania (*Zea mays* Staha) the protein content increased from 9.61% to 10.94% after 72 h germination which is closely related to

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results obtained in this study. Fermentation further increased the protein content (12.05% in Zm 607 and 12.07% in Tamira Pool) which is higher than (8.2 to 9.2% of protein) in *mawe*, a maize based fermented dough, used in Benin and Togo (Hounhouigan *et al.*, 1991). There was no significant difference in the protein contents of maize fermented, and maize that was fermented and then germinated. In comparison to the control, germination combined with fermentation resulted into 162% and 65% increase in protein content of ZM 607 and Tamira Pool A9 respectively. These results show that germination, fermentation, and germination combined with fermentation increased the protein content of maize. Furthermore, the results illustrate that the effects of germination, fermentation, germination combined with fermentation depends on the maize variety since a much greater increase in protein content was detected in ZM 607 than in Tamira Pool A9. It has been reported, however, that germination tends to induce changes in amino acid patterns resulting in improvement in the biological value of proteins (Bhise *et al.*, 1988). The concentration of lysine and tryptophan increases in most maize varieties during germination (Brockway, 2001).

Fat content

The fat content was 6.80 % and 6.70 % in the control samples of Zm 607 and Tamira Pool respectively (Fig 1a and 1b). The fat content of germinated, fermented and germinated and then fermented ZM 607 decreased significantly ($P \leq 0.05$) compared to the control while the fat content of Tamira Pool A9 did not decrease significantly. Similar results were reported by Mtebe *et al.*(1991).

Table 1: Dry matter content of germinated and fermented maize

Sample description	Maize variety	
	Zm 607	Tamira Pool A9
Control	90 ± 0.9	89 ± 0.3
Germinated flour	89 ± 1.4	88 ± 1.3
Fermented flour	91 ± 0.7	91 ± 0.9
Germinated and Fermented	91 ± 1.6	91 ± 0.6

Mean (± standard deviation) of results from at least two independent experiments.

Fig.1a

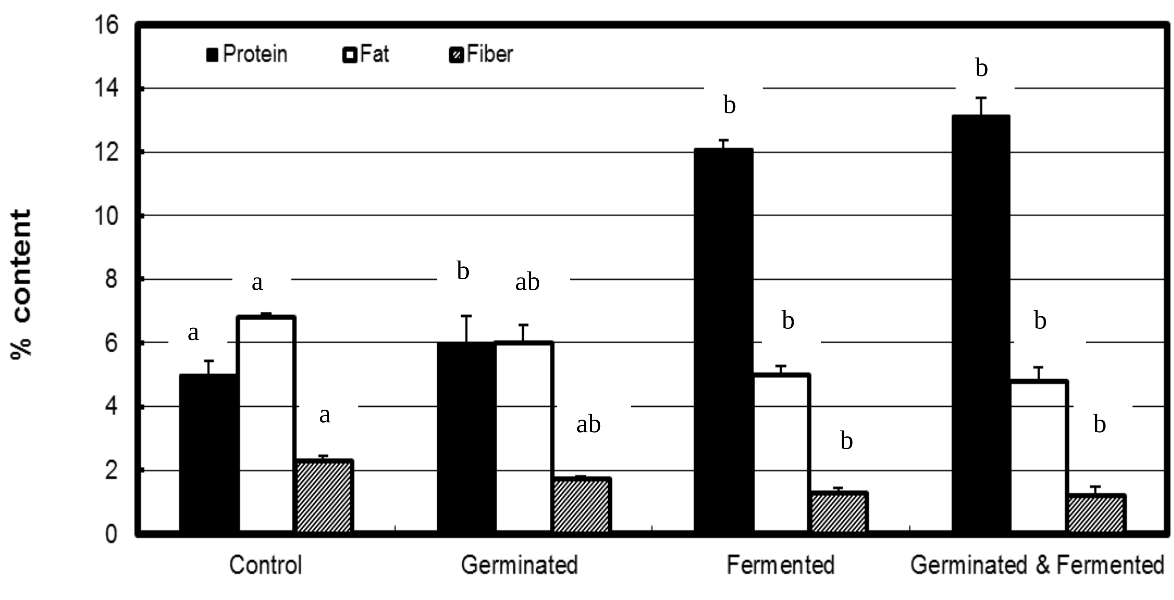

Fig.1b

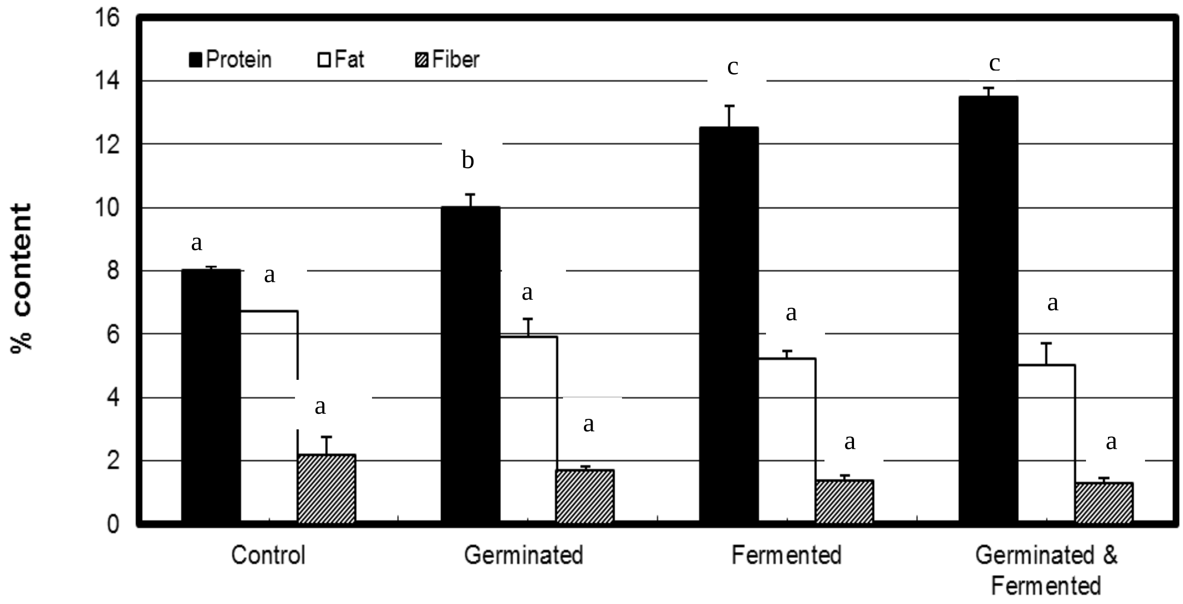

Fig. 1: Effect of germination, fermentation and germination combined with fermentation on the protein, fat and fibre content of maize varieties ZM 607 (Fig.1a) and Tamira Pool A9 (Fig. 1b). The values are means of at least two independent determinations. Error bars represent standard deviation. Means with different lower case letters indicate significant ($P \leq 0.05$) differences amongst different treatments for each maize variety.

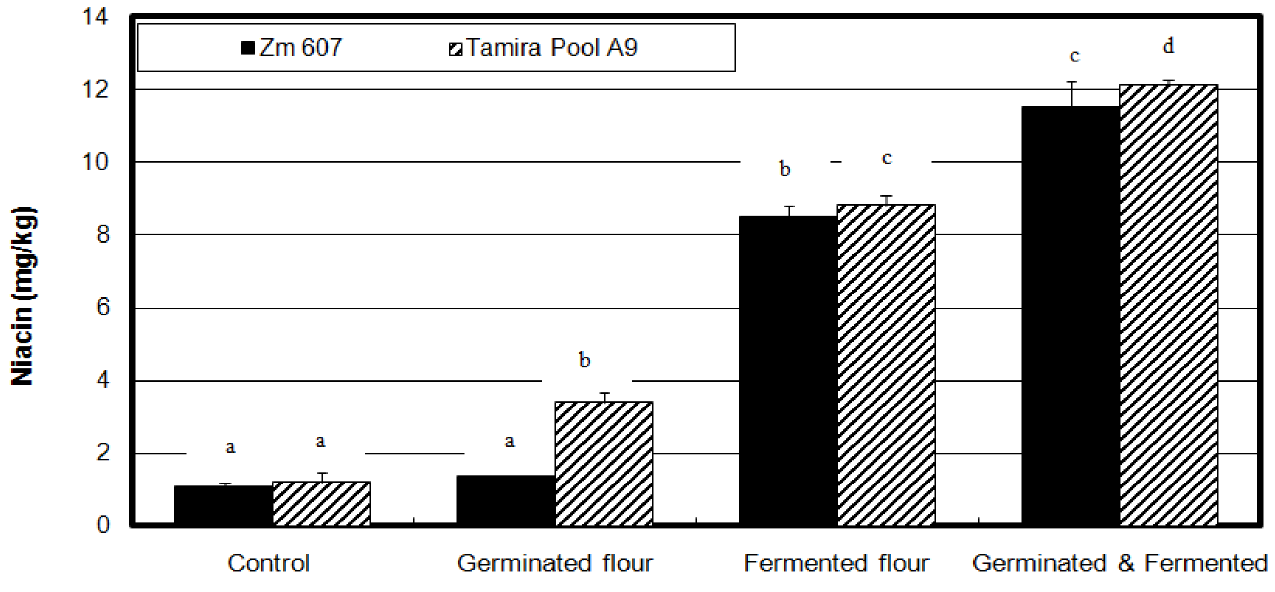

Figure 2: Effect of germination, fermentation and germination combined with fermentation on the niacin content of maize varieties ZM 607 and Tamira Pool A9. The values are means of at least two independent determinations. Error bars represent standard deviation. Means with different lower case letters indicate significant ($P \leq 0.05$) differences amongst different treatments for each maize variety.

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Crude fibre content

The germination and fermentation of both maize varieties resulted in a decrease in fibre content (Fig. 1a and 1b). Germination decreased the fibre content of Zm 607 and Tamira Pool by 25 and 23% respectively. On the other hand fermentation decreased the fibre content of Zm 607 and Tamira Pool by 44 and 37% respectively indicating that fermentation is more effective in reducing fibre of maize than germination. There were insignificant differences ($P \geq 0.05$) between the decrease in fibre content due to germination and the combined effects of fermentation and germination. The fibre content of fermented maize flour range from 1.3 to 1.4% which is within the range of 0.2 to 2.3% in *mawe* (Hounhouigan ,1991).

Niacin content

Germination did not significantly increase the niacin content ZM 607 but significantly ($P \leq 0.05$) increased the niacin content of Tamira Pool A9 from 1.2 to 3.4 mg/kg (Fig 2). Maize samples that were both germinated and fermented and those that were only fermented had a significantly ($P \leq 0.05$) higher niacin content. The niacin content of ZM 607 increased from 1.2 to 11.5 mg/kg (10 fold increase) while that of Tamira Pool A9 increased from 1.2 to 12.1 mg/kg (10 fold increase) after germination and fermentation. Moreover, maize that was germinated and then fermented had a significantly ($P \leq 0.05$) higher niacin content than maize that was either germinated or fermented. These results showed that germination and fermentation can significantly increase the niacin content of maize.

CONCLUSION

In conclusion germination and fermentation significantly increased the protein and niacin content of maize. These processes could play a vital role in improving the nutritional content of germinated and fermented 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. There is need for optimization of germinated and fermented maize products since it has been shown that protein, fat, crude fibre, and ash contents of home produced *mawe* were significantly higher than those of commercial *mawe* (Hounhouigan *et al.*, 1991). Further studies also needed to determine the protein and niacin content of commonly consumed germinated and or fermented African maize products such as *tongwa*, *ogi*, *uji*, *kwoka*, *mahewu*, and *kenkey*, amongst others.

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