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Influence of Heating on Antinutritional Factors on Maize and Rice Cereals

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Abstract
Antinutritional factors are secondary metabolites synthesized in plants, which tend to antagonize nutrition either by causing toxicity or secondary nutritional deficiency of some important nutrients necessary for animal nutrition. Effect of heating regimes on the antinutritional contents of two varieties of rice and maize was determined; boiled for 30, 60, 90 and 120 minutes. The samples were sun-dried and levels of the antinutrients were determined using reported procedures. Rice (foreign): phytate – 8.92 ± 1.24, Oxalate - 3.15 ± 0.45, Tannins – 4.44 ± 0.89, For rice (Local): Phytate – 6.03 ± 1.07, Oxalate – 2.05 ± 0.26, Tannins – 2.49 ± 0.36, Maize (White): Phytate – 7.23 ± 0.26, Oxalate – 6.45 ± 1.13, Tannins - 4.66 ± 0.17 and Maize (Red): Phytate – 6.90 ± 0.71, Oxalate – 4.05 ± 0.45 and Tannins-8.58±0.13. Heating for 120 minutes decreases the levels of antinutrients to; Rice (Foreign): Phyate – 5.59. ± 0.16, Oxalate – 1.36 ± 0.19, Tannins – 1.57 ± 0.13, Rice (Local): Phytate – 0.29 ± 0.07, Oxalate – 0.33 ± 0.09, Tannins – 0.52 ± 0.31, Maize (White): Phyate – 3.00 ± 0.08, Oxalate – 1.37 ± 0.31, Tannins – 1.92 ± 0.09 and Maize (red): Phytate – 3.01 ± 0.08, Oxalate – 1.27 ± 0.60 and Tannins 3.19 ± 0.23. The data were analyzed by analysis of variance using SPSS 20. For the analysis, there was significant difference ($P<0.05$) between rice and maize cereals, but no significant difference ($P<0.05$) between both the cultivars of rice and maize. Similarly, there was significant difference ($P<0.05$) in the effect of heating on the two cereals, but no significant difference ($P<0.05$) in the effect of heat between the red and white maize as well as local and foreign rice. The results showed that decrease in the levels of antinutritional contents is proportional to the heating time in rice and maize samples.
Key words; *Heating Regime, Antinutritional, Maize, Rice*

INTRODUCTION

Nutrition is a prerequisite for the maintenance of health and is seen as the sum total of the processes by which living organism receive and utilize the materials necessary for their survival, growth and repair of worn out tissues (Mattila *et al.*, 2018). Antinutritional factors (antinutrients) are naturally occurring substances synthesized in plants (Mattila *et al.*, 2018). Antinutritional factors are deleterious when present in humans or animals' food; they tend to antagonize nutrition, either by causing toxicity or secondary nutritional deficiency via chelation of some important nutrients that are necessary for animal nutrition. Moreover, some antinutrients may both be toxic and have chelating properties (Mc Donald *et al.*, 1995; Mattila *et al.*, 2018).

Food processing involves any treatment given to food commodity between its point of harvest and consumption. At every stage of food processing, nutrients (and antinutrients) are usually affected because of their sensitivity to pH, oxygen, heat, light and other factors (Okaka, 1992).

Phytic acid is the storage form of phosphorous in many plant tissues. Phytic acid has been defined as a phosphorous containing organic acid that acts as a strong chelator of important minerals like calcium, magnesium, iron and zinc, leading to secondary nutritional deficiency in monogastric animals (Gupta *et al.*, 2015), and can therefore contribute to mineral deficiencies in people whose diets rely on these foods for their mineral intake (Gupta *et al.*, 2015).

The term tannins, is applied to any large polyphenolic compound containing sufficient hydroxyls and other suitable groups (such as carboxyls) to form strong complexes with proteins and other macromolecules (Bajaj, 1999; Mihrete 2019). Tannins are therefore, either bind and precipitate or shrink proteins (Harold, 2004) and act as metal ion chelators, leading to mineral deficiency (Mihrete, 2019).

Oxalate is ubiquitous in the plant kingdom (Mihrete, 2019). The name comes from oxalis (wood sorrel), a plant from which it was first isolated. It is the deprotonated charged form of oxalic acid, with chemical formula of $C_2O_4^{2-}$ (Franceschi and Nakata, 2005). High levels of oxalate in any edible parts of plants significantly lower nutritional quality (Liebman and Costa, 2000), as it chelates various minerals such as sodium, calcium, potassium, magnesium, to form a complex called oxalate salt (Liebman and Costa, 2000; Mihrete, 2019). The salt of calcium (calcium oxalate) is the most important in relation to the toxicity associated with this compound. Unlike other oxalates, calcium oxalate is not soluble in water and therefore, high levels has the potency to precipitate in the kidney or urinary tract as crystals of calcium oxalate, which could results to the formation of kidney stones (Liebman and Costa, 2000; Mihrete, 2019).
Therefore, the aim of this work is to elucidate whether heating influence the levels of phytic acid, tannins and/or oxalate in various cultivars of some of our commonest staple; maize and rice.

MATERIALS AND METHODS

Chemicals
All chemicals used were of analytical grade.

Samples Collection
The grain samples (rice, maize) were procured from Shehu Shagari central market, Sokoto Sokoto State-Nigeria. The samples were identified at the department of Crop Science, Faculty of Agriculture, Usmanu Danfodiyo University Sokoto, Sokoto State-Nigeria.

Sample Treatment and Determination of Antinutrients
Five hundred grams (500g) of each grain samples were separately boiled in water (~95°C) for 30, 60, 90 and 120 minutes. The samples were sun-dried, pounded and appropriately labeled.
Values of three antinutrients; phytate, tannins and oxalate were determined in both fresh and heated samples as follows.

Phytate
Phytate was determined using Reddy and love method (1999), which is based on the reaction between HCl, ammonium thiocyanate and $FeCl_3$ solution resulting in a brownish-yellow colour that persisted for 5 min.

Oxalate
Day and Underwood (1986) method was used in determining oxalate levels. This method is based on precipitation of oxalate as calcium oxalate; the concentration was determined by titration with potassium permanganete resulting in a faint pink colour that persisted for 1 min.

Tannins
Trease and Evans (1978) method was used that involves the reaction of tannin with Dennis reagent, which resulted to a dark coloured complex measured spectrophotometrically at 520nm.

Statistical Analysis
Data was analysed using SPSS 20, and the results were presented as mean ± standard deviation.

RESULTS

Tables 1 to 5 below are showing the antinutrients content of grains before heating, and those of the grains after heating.

Table 1: Antinutrients Levels of Cereals Studied. (mg)

Samples	Phytate	Oxalate	Tannins
Rice (foreign)	8.92 ± 1.24	4.15 ± 0.45	4. 44 ± 0.89
Rice (Local)	6.03 ± 1.07	2.05 ± 0.26	2.49 ± 0.36
Maize (red)	6.90 ± 0.71	4.05 ± 0.45	8.58 ± 0.13
Maize (White)	7.23 ± 0.26	6.45 ± 1.13	4.66 ± 0.17

Values are mean ± standard deviation.
Table 1 shows the antinurients levels in various cereals prior to heating.

Table 2: Effects Of Heating Time on Levels (mg%) of Antinutrients of Cereals Studied

Rice (Foreign)	30 mins	60 mins	90 mins	120 mins
Phytate	7.31 ± 0.08	6.66 ± 0.33	6.06 ± 0.16	5.59 ± 0.16
Oxalate	3.98 ± 0.38	3.10 ± 0.23	2.58 ± 0.09	1.36 ± 0.19
Tannins	3.82 ± 0.31	2.92 ± 0.31	2.47 ± 0.31	1.57 ± 0.31

Values are mean ± standard deviation.
Table 2 shows the decrease in the antinurients levels (when compared with Table 1) in Rice (foreign) with increase in heating time.

Table 3: Effects of Heating Time on Levels of (Mg%) Antinutrients of Cereals Studied

Rice (Local)	30 mins	60 mins	90 mins	120 mins
Phytate	0.83 ± 0.16	0.71 ± 0.16	0.65 ± 0.08	0.29 ± 0.07
Oxalate	0.91 ± 0.09	0.73 ± 0.14	0.52 ± 0.09	0.33 ± 0.09
Tannins	1.12 ± 0.31	0.67 ± 0.31	0.63 ± 0.31	0.52 ± 0.31

Values are mean ± standard deviation.

Table 3 shows the decrease in the antinurients levels (when compared with table 1) in Rice (local) with increase in heating time.

Table 4: Effects of Heating Time on Levels of (Mg%) Antinutrients of Cereals Studied

Maize (Red)	30 mins	60 mins	90 mins	120 mins
Phytate	5.87 ± 0.16	4.63 ± 0.16	3.57 ± 0.08	3.01 ± 0.08
Oxalate	3.72 ± 0.31	3.22 ± 0.31	3.02 ± 0.38	1.27 ± 0.60
Tannins	6.05 ± 0.91	5.10 ± 0.09	4.16 ± 0.19	3.19 ± 0.23

Values are mean ± standard deviation.

Table 4 shows the decrease in the antinurients levels (when compared with Table 1) in Maize (red) with increase in heating time.

Table 5: Effects of Heating Time on Levels of (mg%) Antinutrients of cereals Studied

Maize (white)	30 mins	60 mins	90 mins	120 mins
Phytate	5.23 ± 0.16	4.92 ± 0.16	3.85 ± 0.05	3.00 0.08
Oxalate	5.17 ± 0.31	4.72 ± 0.31	3.82 ± 0.28	1.37 ± 0.31
Tannins	4.37 ± 0.04	3.34 ± 1.09	2.87 ± 0.28	1.92 ± 0.09

Values are mean ± standard deviation.

Table 5 shows the decrease in the antinurients levels (when compared with Table 1) in Maize (white) with increase in heating time.

DISCUSSION

Table 1 shows the level of antinutrients of cereals studied. Rice (Foreign):- phytate - 8.92 ± 1.24, oxalate - 3.15 ± 0.45, tannins - 4.44 ± 0.89, Rice (local), phytate - 6.03 ± 1.07, oxalate - 2.05 ± 0.26, tannins - 2.49 ± 0.36, Rice (Local):- phytate - 6.03 ± 1.07, oxalate - 2.05 ± 0.26, tannins - 2.49 ± 0.36, maize (red):- phytate - 6.90 ± 0.71, oxalate - 4.05 ± 0.45, tannins - 8.58 ± 0.13, maize (White): phytate - 7.23 ± 0.26, oxalate -6.45 ± 1.13 and tannins - 4.66 ± 0.17. While result obtained in table 2, 3, 4 and 5 showed the effects of heating time levels of antinutrients of cereal used. After heating for 120 minutes the levels of antinutrients decreased to: Rice (Foreign): phytate – 5.59 ± 0.16, oxalate- 2.36 ± 0.19, tannins – 1.57 ± 0.31, rice (Local):- phytate – 0.29 ± 0.07, oxalate – 0.33 ± 0.09, tannins – 0.52 ± 0.31, maize (red):- phytate – 3.01 ± 0.08, oxalate – 1.27 ± 0.60, tannins- 3.19 ± 0.23 and maize (white): phytate – 3.00 ± 0.08, oxalate- 1.37 ± 0.31 and tannins – 1.92 ± 0.09. The results indicated that there is decrease in all the antinutrients of all the cereals studied with increase in heating time. Very long heating time is also having damaging effects on other nutrients, as the longer the heating duration the lower the protein contents and this might be due to the leaching out of non protein nitrogen (Adeyimi, and Mustafa 1979). The heating duration of 60-90 minutes is however recommended so that high quality is assured and sustained.

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