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Changes in the phytate, calcium and zinc concentrations during the traditional processing of maize into "Ogi" and "Eko"

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ABSTRACT: The changes in the level of phytate and free minerals (calcium and zinc) during the processing of maize into "Ogi" and "Eko" were studied. The concentration of phytate decreased significantly with each stage of processing ($P < 0.001$). the method effectively reduced the phytate by 87.5% in 'Ogi' and 87.4% in 'Eko'. Milling and subsequent separation of the chaff accounts for most of the decrease observed. The free minerals released during the processing appearred mostly in the by-products, namely, steeping water supernatant and chaff. The nutritive value of 'Ogi' and 'Eko' can be improved by incorporating the supernatant and the chaff into the final product.

Key Words: Phytate; Maize (*Zea mays*); Maize fermentation; Maize milling; 'Ogi'; 'Eko'; Minerals; Zinc; Calcium.

Introduction

Maize (*Zea mays*) is a cereal grain which is widely consumed in various form in Nigeria. In the southern part of the country, it is processed into a staple diet called 'Ogi' which is a fermented product. When 'Ogi' is mixed with boiling water and heated, it forms a paste of uniform consistency called 'Eko'. This product is used effectively as a weaning diet for infants and as breakfast and convalescent food for children and adults.

However, in addition to their nutritional benefits, cereal grains and legumes contain phytic acid, myo-inositol hexa-kis-dihydrogen phosphate and its derivatives. A level of approximately 5% by weight has been reported in cereals and legumes (De Boland *et al*., 1975). Many studies have shown that phytic acid forms insoluble complexes with metal cations like calcium, zinc, iron, manganese and copper, thereby making these metals unavailable or only partially available for absorption (O'Dell and Savage, 1960; Welch *et al*., 1974, 1975; Erdwan *et al*., 1977; Graf and Eaton, 1984; Nolan and Duffin, 1987). This problem becomes very significant, especially when two or more cations are present in that a synergistic binding effect can occur. This seems to be particularly true for zinc and calcium (O'Dell, 1969). Although evidence has been presented that man possesses phytase, this enzyme does not seem to play a significant role in phytate digestion in humans. It appears that dietary phytase may be an important factor for phytate hydrolysis (Sauderberg and Anderson, 1987).

Several methods have been employed to remove phytate, or at least reduce its level in food during processing. These methods include soaking in water or salt solutions, boiling, cooking, roasting, baking, autoclaving, sprouting or gemination as well as mechanical processing like milling (De Boland *et al*., 1975; Adewusi *et al*., 1991). In corn, 89% of the phytate is concentrated in the germ portion and can be removed by milling, followed by germ separation (Reddy *et al*., 1970). The processing of maize into 'Ogi' and 'Eko' involves steps like steeping, fermentation, milling, germ separation and boiling. The presence of unhydrolysed phytate in these products may reduce the bioavailability of minerals like iron, calcium and zinc which are present. This paper examines the changes in the level of phytate abd free minerals during this traditional technological process.

Materials and Methods

The maize used in this study was *Zea mays* (T2SR-Y) obtained from the National Seed Service, Federal Department of Agriculture, Ibadan, Oyo State, Nigeria. All glasswares were washed with boiling, concentrated nitri acid and rinsed with distilled-deionised water.

Two hundred grams of the maize was washed with distilled-deionised water to remove dirt and bad kernels from the grains. the grains were then steeped in 400 cm^3 of water for 72 hours. The steep water was decanted into a container and measured. the soaked maize was milled using a speed controlled blender with plastic blades and 80 cm^3 of distilled-deionised water was added during milling in order to form a paste. Afterwards, the paste was sieved using a muslin cloth along with 300 cm^3 of distilled water. The chaff, consisting of the germ and the outer coverings of the maize, was separated and the fine paste ('Ogi') was allowed to settle. The supernatant ('Omidun') was carefully decanted and measured. Fifty grams of the fresh 'Ogi' was made into porridge ('Eko') by adding 100 cm^3 of boiling water and stirring thoroughly. Samples were taken at the following stages for analysis of moisture and free minerals:

1. Dry untreated maize.
2. Steeped maize.
3. Steeping water
4. Steeped and milled maize.
5. Fine paste ('Ogi').
6. Chaff.
7. Supernatant ('Omidun').
8. Porridge ('Eko').

Moisture was determined by the method of the AOAC (1990) in all the solid samples. The method of Lata and Eskin (1980) was used for the determination of phytate. Five grams of the dry solid sample was extracted with 100 cm^3 of 2.4% HCl for 1 hr at room temperature, using a mechanical shaker. The slurry obtained was centrifuged and the clear supernatant was used for phytate analysis. The extract was passed through an anion resin IRA 400 (chloride) and the phytate was eluted with 0.7 M NaCl into a standard flask. The eluate was treated with Wade's reagent and the phytate was determined colorimetrically. The phytate concentration was calculated from a standard curve using sodium phytate (inositol hexaphosphoric acid, corn type V, 97% pure sodium salt, Sigma Chemical Co) as standard.

The total minerals in the dry whole maize was analysed from solutions obtained by first dry ashing at 500^oC and dissolving the ash in a minimum volume of 1:1 nitric acid and then made up to 1000 cm^3 with distilled-deionised water. The free minerals at each stage of processing was determined by passing 60 cm^3 of the extract through a column of Amberlite resin IRA 400 present in hydroxyl form. The first 25 cm^3 of the eluate was discarded and the subsequent eluate was collected into a standard volumetric flask. Zinc and calcium were determined by means of atomic absorption spectrophotometry using Perkin Elmer spectrophotometer model 403. Standard additions were carried out to eliminate matrix interference.

Results and Discussion

The results of the changes in the concentration of phytate during the processing of maize into 'Ogi' and 'Eko' is presented in Table 1. Phytate expressed in mg/g dry weight was found to decrease significantly with ech stage of processing ($P < 0.01$). The mean decrease from the dry maize to the fine paste or 'Ogi' was 21.00 ± 0.63 to 4.53 ± 0.61 mg/g. This represents a decrease in the phytate concentration by 78.5%. Steeping of the maize in water for 72 hours accounts for 20.3% of this decrease. During the process of steeping, fermentation occurs due to the combined activities of the endogenous phytase of the maize and the phytase of the bacteria involved in the fermentation process (Reinhold, 1975). Milling of the steeped maize accounts for 32.6% of the decrease in the phytate concentration. the tissue damage during the milling process increase the surface area thereby bringing the endogenous phytase enzyme into more contact with the phytate substrate. This results in the increase in phytate hydrolysis observed.

Table 1: Mean values of moisture and phytate concent during the processing of maize into 'Ogi' and 'Eko'.

Stages of Processing	Moisture (%)[1]	Phytate (mg/g)[2]
Dry maize	13.0	21.00 ± 0.63
Soaked maize	34.0	16.73 ± 0.73
Soaked and milled maize	53.4	9.90 ± 1.03
'Ogi'	64.0	4.52 ± 0.61
Steeping water	NA	ND
Supernatant water	NA	0.70 ± 0.00
Chaff	60.0	5.53 ± 0.67
'Eko'	87.0	2.65 ± 0.40

[1]Values are means of duplicate determinations.

[2]Values are means ± SD of four determinations.

ND = Not detected

NA = Not applicable

The milled maize was then sieved and the outer coverings as well as the germ were separated out as chaff. This process accounted for a further decrease in the phytate by 25.6%. The resulting fine paste obtained is called 'Ogi' and this product contains only 21.5% of the initial phytate present in the dry maize. Most of the phytate in cereals are located in the aleurone layer (bran). Therefore, milling and subsequent separation of the chaff results in reduction in the level of phytate. Some of the phytate appear in the chaff and the supernatant.

The results of this study show 78.5% reduction of phytate in the processing of maize into 'Ogi' by the traditional method. Adewusi *et al*. (1991) reported 88% reduction in the processing of yellow maize into 'Ogi' and 72% reduction in the processing of white maize into 'Ogi'. The cooking of 'Ogi' to make porridge known as 'Eko' accounts for additional 8.9% decrease in the phytate. The reduction of phytate level during the stages of processing is presented in Table 2 and graphically in Fig. 1. These results show that the process of milling and subsequent separation of the chaff are the most effective in reducing the phytate level.

Table 2: Percentage reduction of phytate at various stages of processing.

Stages of Processing	Percentage	Percentage reduction
Dry maize	100	—
Soaked maize	79.7	20.3
Soaked and milled maize	47.1	32.6
'Ogi'	21.5	25.6
'Eko'	12.6	8.9
Total percentage reduction	—	87.4

Table 3 shows the concentration of total free levels of calcium and zinc and this is represented graphically in Fig. 2. In the dry maize, 99 mg/kg of calcium occurs as free mineral out of a total concentration of 283 mg/kg. Similarly, for zinc, 530 mg/kg occurs as free metal out of a total concentration of 6050 mg.kg. During the steeping of maize in water, a lot of free metals are released into the steeping water. The increase in the concentration of free calcium and zinc from dry maize to supernatant is statistically significant)$P < 0.001$ for calcium and $P < 0.001$ for zinc). The same observation was made for dry maize to chaff ($P < 0.001$ for both calcium and zinc). However, very little increase of calcium and zinc was observed in the fine paste ('Ogi) (Table 3). This is because the free minerals released during the processing mainly go into the by-products, namely chaff and supernatant. The chaff is normally discarded and the free minerals contained in it are lost to the consumer. Some of the supernatant is traditionally used to rpepare the porridge ('Eko') while some people use ordinary water for this purpose. The use of the supernatant for preparing 'Eko' should be encouraged in order to take advantage of its high mineral content. Also, the addition of some chaff to the fine paste or 'Ogi' before cooking to produce the porridge is highly recommended. This practice will not only improve the mineral content of the product but will also increase the fibre content.

Conclusion

This study has shown that the traditional method used for processing of maize into 'Ogi' and 'Eko' is effective and significantly reduced the phytate concentration ($P < 0.001$). The nutritional significance is that phytate hydrolysis increases the concentration of free minerals, namely calcium and zinc. However, these minerals are mostly lost into the by-products like chaff and supernatant. there is need to find ways of incorporating these by-products into the final product in order to increase its nutritional value.

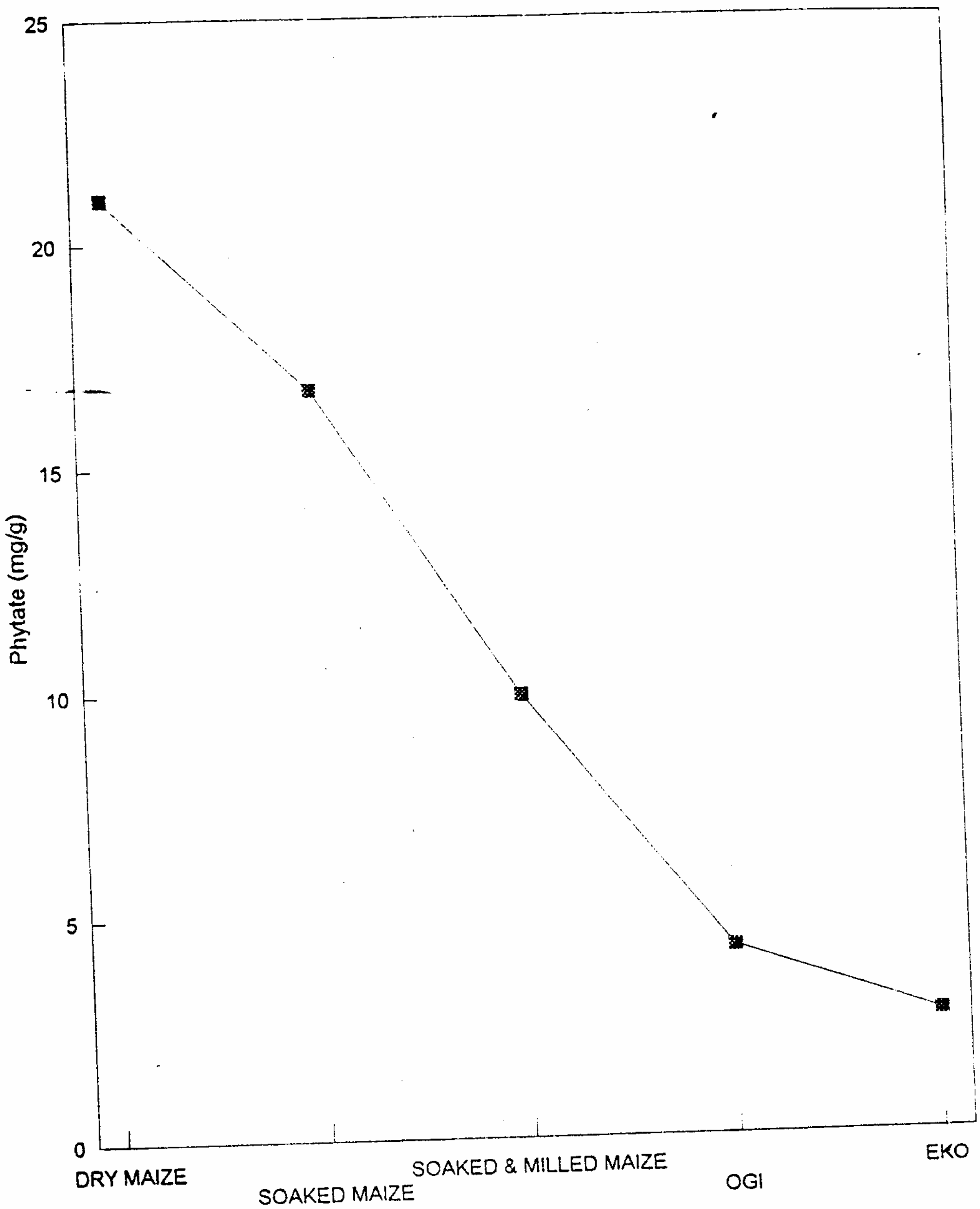

Fig. 1: Changes in phytate content during the processing of maize into 'Ogi' and 'Eko'.

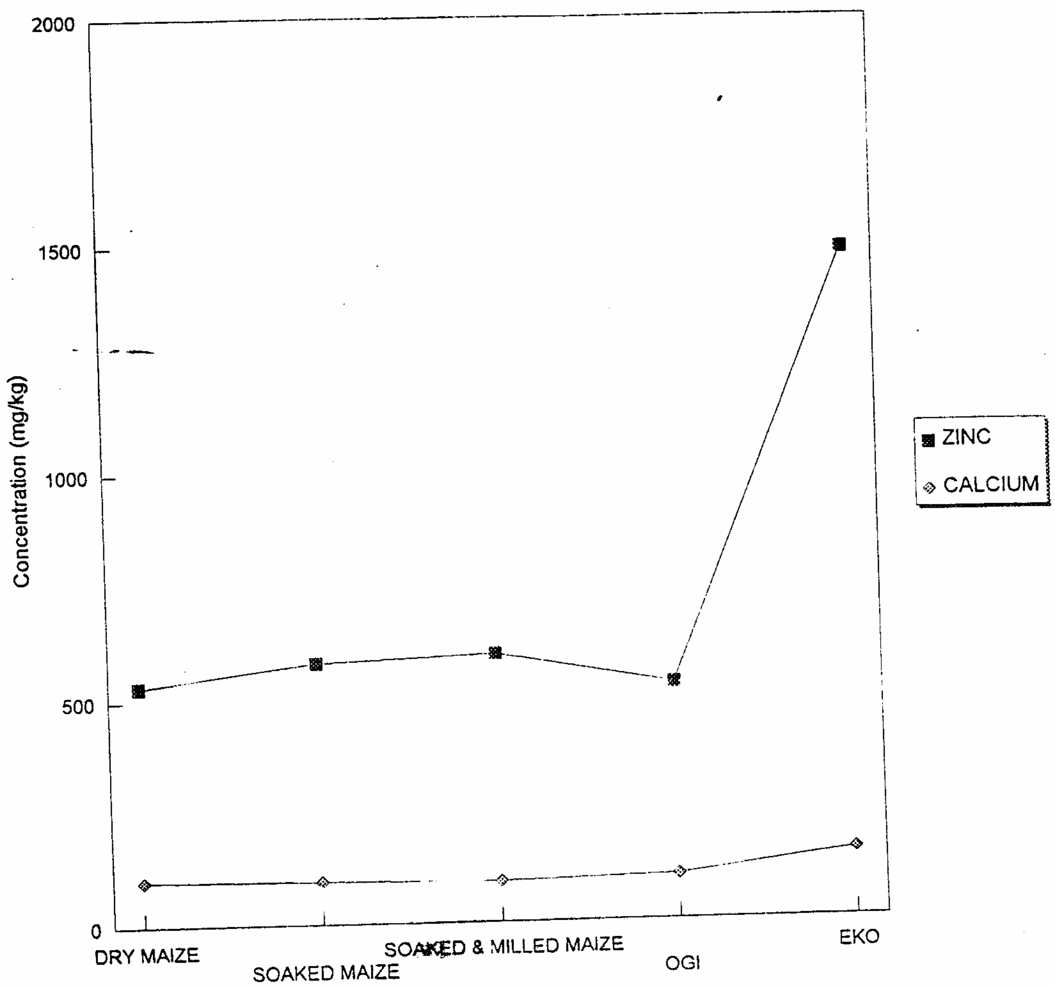

Fig. 2: Changes in the concentration of free calcium and zinc during the processing of maize into 'Ogi' and 'Eko'.

Table 3: Level of free calcium and zinc during the preparation of maize into 'Ogi' and 'Eko'.

Stages of Processing	Calcium (mg/kg)	Zinc (mg/kg)
Dry maize (Total mineral)	283.0 ± 2.5	6050 ± 10.5
Dry maize	99.0 ± 1.2	530 ± 4.2
Soaked maize	95.6 ± 1.5	580 ± 4.7
Soaked and milled maize	90.7 ± 0.9	587 ± 5.2
'Ogi'	100.0 ± 1.3	528 ± 4.3
Steeping water (mg/dm^3)	149.0 ± 1.9	790 ± 6.9
Supernatant water (mg/dm^3)	134.0 ± 1.7	1188 ± 7.1
Chaff	180.0 ± 2.2	990 ± 6.7
'Eko'	152.0 ± 1.7	1485 ± 8.5

Values are means ± SD of four determinations.

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