COMPARATIVE EFFECTS OF SPROUTING ON PROXIMATE, MINERAL COMPOSITION AND FUNCTIONAL PROPERTIES OF WHITE AND YELLOW SWEET MAIZE (ZEA MAYS VAR SACCHARATA)

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Abstract
The effects of sprouting on proximate, mineral composition and functional properties of white and yellow sweet maize were evaluated. The maize kernels obtained from Agricultural Input Supply Agency, Ministry of Agriculture, Ado-Ekiti, Nigeria were sorted and divided into two portions. The first portion was soaked for 24 hours after which it was spread on trays lined with cloth and kept wet by frequent spraying of water each morning and evening for 2 days. The sprouted maize grains were oven-dried at 60°C to constant weight and milled into flour. The second portion was processed into flour without sprouting, using the same method. Each of the portions was analyzed for proximate, mineral compositions and functional properties using standard methods. Sprouting of both white and yellow sweet maize grains resulted in significant increase (p<0.05) in crude protein, while the increase in ash is not significant (p>0.05). Conversely, there was significant decrease (p<0.05) in carbohydrate, fat and crude fibre. With the exception of iron, which was found not to be significant (p>0.05), all other analyzed minerals (i.e. sodium, potassium, calcium and magnesium) exhibited significant increase (p<0.05) in the sprouted samples. For the functional properties, both white and yellow varieties of the sprouted flour samples exhibited decrease in bulk density from 0.670±0.001 to 0.669±0.004 and 0.068±0.001 to 0.067±0.006 respectively. The sprouted flour also had a lower swelling index from 1.290±0.001 to 1.200±0.116 and 1.450±0.001 to 1.300±0.058 for both white and yellow sweet maize. Increase in water absorption capacity from 1.800±0.058 to 1.810±0.001 for white and 1.590±0.002 to 1.750±0.058 for yellow maize was observed. The results showed that the sprouting process improved the nutrient composition and enhanced the functional properties of both white and yellow sweet maize, with the white variety being found to be slightly better.

Keywords: effect, sprouting, sweet maize, composition and functional properties

INTRODUCTION
Maize or corn (Zea mays) is a cereal crop that is grown usually throughout the world in a range of agro-ecological environment. Introduced into Africa by the Portuguese in the 16th century, maize has since become one of the Africa’s most important staple food crops. Worldwide production of maize is 785 million tons, with the largest producer- the United States of America producing 42%; Africa 6.5% with Nigeria being the largest African producer with nearly 8 million tons (Gill, 1980).

Among the cereals, maize represents the staple food for most part of the population of Africa, Nigeria inclusive. The kernel is used both for human consumption and for livestock feed (Ikem, 1991; Oyarekua and Adeyeye, 2009; Ikem and Amusa, 2010). Maize is eaten either at the green stage, as boiled or roasted ears, or dried and prepared into a jelly-like ‘pap’ or ‘eko’ (maize grill) (Aliko et al., 1988). Preparations and uses of the maize grains varied from group to group in Nigeria, though at times with some similarities.

Nutritionally, maize is a relatively poor cereal when it comes to the quality of its protein, because it has limiting amounts of two essential amino acids, lysine and tryptophan (Azvedo et al., 1997). Maize grains are rich in vitamins A, C, and E, carbohydrates, essential minerals, dietary fibre, and contains 9% protein (Halley, 1983). Maize comes in several varieties, such as popcorn, dent corn, flint corn, waxy corn, amylo maize, flour maize and sweet maize. Sweet maize (Zea mays var saccharata) kernels are white or yellow and may be wrinkled or become caramelized in colour when fully mature.

Corn flour is an important food ingredient and its industrial and food uses would increase if appropriate applications were developed. One way of increasing uses of raw materials is to promote functional modifications. As new food systems are developed, new ingredient modifications and new techniques for these modifications would be needed. Sprouting process is known as a way to promote changes in the biochemical, sensorial and nutritional characteristics of cereal grains (Lorenz, 1980; Colmeneros de Ruiz and Bressani, 1990; Mora-Escobedo et al., 1991). Sprouting or germination has been reported to improve digestibility, bioavailability of vitamins, minerals, amino acids, proteins and phytochemicals, and decrease anti-nutrients and starch of some cereals and legumes (Asiedu et al., 1992; Helland et al., 2002 and Egli et al., 2004) and thereby improve protein and iron absorption. Moreover, α-amylase activity is increased during germination of cereals. This enzyme hydrolyzes amylase and amylopectin to dextrin and maltose, thus reducing the viscosity of thick cereal porridges without dilution with water while...
simultaneously enhancing their energy and nutrient densities (Gibson et al., 1998).

The objective of this study is to compare and contrast the effect of sprouting on the nutritional and functional properties of white and yellow sweet maize.

MATERIALS
The yellow and white sweet maize kernels (Zea mays var saccharata) were purchased from Agricultural Input Supply Agency, Ministry of Agriculture, Ado-Ekiti, Ekiti State, Nigeria.

METHODS
Sample Preparation
Yellow and white sweet maize grains were sorted and divided into two portions. The first portion was soaked for 24 hours after which it was spread on trays lined with cloth and kept wet by frequent spraying of water at every morning and evening for 2 days. The sprouted maize grains were oven-dried at 60°C to constant weight and milled into flour in hammer mill.

The second portion was processed into flour without sprouting, using the same method. The seed flours were labeled as follows:
- UYM: Unsprouted Yellow Maize flour
- SYM: Sprouted Yellow Maize flour
- UWM: Unsprouted White Maize flour
- SWM: Sprouted White Maize flour

ANALYSIS
Proximate Composition
The proximate analysis for the sweet maize flour samples were carried out using Association of Official Analytical Chemists (AOAC, 2005) methods. Carbohydrate was estimated by subtracting the ash, protein, crude fibre and fat percentages from 100%.

DETERMINATION OF FUNCTIONAL PROPERTIES
Water Absorption Capacity
Water absorption capacity (WAC) of the flours was determined by the method of Beuchat et al., (1977). Ten milliliter (10 ml) of water was added to 1.0 g of each sample in a beaker. The suspension was stirred for 5 minutes at 1000 rpm on magnetic stirrer hot plate, after which it was transferred into centrifuge tubes and centrifuged at 3500 rpm for 30 minutes; the volume of the supernatant obtained was measured. The density of the water was assumed to be 1g/ml. The water absorbed by the seed flour was calculated as the difference between the initial water used and the volume of the supernatant obtained after centrifuging.

Bulk Density (BD)
The bulk density of the maize flours was determined by the method of Okaka and Potter (1979) with modification. A specified quantity of the sample of each of the differently processed maize flour was put into an already weighed 10 ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The new mass of the sample and measuring cylinder was recorded. Both the volume and mass of the flour sample were determined.

Swelling Capacity (SC)
The swelling capacity was determined as described by Leach et al. (1959) with modifications for small samples. One gram of the flour sample was mixed with 10ml distilled water in a centrifuge tube and heated at 80°C for 30mins. It was continually shaken during the heating period. After heating, the suspension was centrifuged at 500rpm for 30mins. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated as: Swelling power = weight of the paste/weight of dry flour.

MINERAL COMPOSITION
Mineral composition namely: K, Ca, Fe, Na and Mg were determined by wet ashing method (AOAC, 2005). Sodium and Potassium were determined using a flame photometer as described by AOAC (2005). Calcium, iron and magnesium of the flour were determined using x-ray Fluorescence (XRF).

STATISTICAL ANALYSIS
All samples were in three replicates. The statistical analyses were conducted using one-way ANOVA procedures. Statistical differences in samples were tested for at p<0.05. Duncan’s new Multiple- Range Test (DNMRT) was used to separate the mean values. All analyses were done with SPSS (11.0) software.

RESULTS AND DISCUSSION
Proximate Composition
The results of the proximate composition of the sprouted and raw white and yellow sweet maize (Zea mays var saccharata) are shown in table 1 below. Comparatively, the protein content of both white and yellow sprouted sweet maize were significantly (p<0.05) higher than that of the unsprouted maize samples. This could be as a result of mobilization of stored nitrogen of maize to aid sprouting. It may also be as a result of synthesis of enzymes or a compositional change following the degradation of other constituents. This observation is consistent with the findings of Malleshi et al., (1989) who reported significant increase in protein content of weaning food formulated from sprouted cereals. Other prominent researchers have also observed significant increase in protein content with seed sprouting (Enujiugha et al., 2003; Fasasi, 2009; Ijarotimi and Keshinro, 2011). The observed reduction in carbohydrate, crude fibre and crude fat contents with germination could be due to their utilization as energy sources in the sprouting process (Fasasi, 2009; Ijarotimi and Keshinro, 2011). The lipolytic enzymes hydrolyze fats to simpler products during sprouting, which can be used as a source of energy for the developing embryo. The reduction in fat content is of particular interest as maize oil is reported to be rich in essential fatty acids (Adeyemo et al., 1992) which play a very important role in the proper development of brain cells in infants and children. Thus if germination adversely affects the quantity of essential fatty acids of the grains, the need
for supplementation becomes more crucial. This decrease in fat content also implies an increased shelf-life for the sprouted seeds compared to the unsprouted ones. The ash content also increased with sprouting as similarly observed by Obasi et al. (2009). In general, white sweet maize tend to have slightly more crude protein, crude fat and crude fibre than the yellow type, while the yellow type is slightly richer in ash and carbohydrate.

Table 1: Effect of Sprouting on the Proximate Composition (%) Dry weight of Sweet white and yellow maize (Mean ± SE)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Fibre (%)</th>
<th>Carbohydrate (%)</th>
<th>Energy (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UWM</td>
<td>6.29±0.006</td>
<td>10.23±0.133</td>
<td>4.21±0.121</td>
<td>2.16±0.092</td>
<td>2.90±0.006</td>
<td>79.80±0.058</td>
<td>400.87±0.006</td>
</tr>
<tr>
<td>SWM</td>
<td>6.13±0.069</td>
<td>12.34±0.069</td>
<td>3.89±0.035</td>
<td>2.24±0.127</td>
<td>1.89±0.064</td>
<td>77.90±0.127</td>
<td>402.94±0.186</td>
</tr>
<tr>
<td>UYM</td>
<td>6.16±0.064</td>
<td>10.00±0.005</td>
<td>4.20±0.116</td>
<td>2.18±0.064</td>
<td>2.89±0.064</td>
<td>80.73±0.069</td>
<td>400.72±0.116</td>
</tr>
<tr>
<td>SYM</td>
<td>6.16±0.069</td>
<td>12.13±0.075</td>
<td>3.88±0.005</td>
<td>2.27±0.127</td>
<td>2.69±0.005</td>
<td>79.03±0.017</td>
<td>399.56±0.116</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations. Mean values in the same column followed by dissimilar letters are significant at P<0.05.

Key: UWM: Unsprouted white maize. UYM: Unsprouted yellow maize. SWM: Sprouted white maize. SYM: Sprouted yellow maize.

Table 2: Effect of Sprouting on functional properties of white and yellow sweet maize flour

<table>
<thead>
<tr>
<th>Samples</th>
<th>Bulk density</th>
<th>Mean ± S.E.</th>
<th>Water absorption capacity</th>
<th>Oil absorption capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>UWM</td>
<td>0.069±0.004</td>
<td>1.290±0.001</td>
<td>1.800±0.058</td>
<td>0.552±0.001</td>
</tr>
<tr>
<td>SWM</td>
<td>0.670±0.001</td>
<td>1.200±0.116</td>
<td>1.810±0.001</td>
<td>0.736±0.002</td>
</tr>
<tr>
<td>UYM</td>
<td>0.068±0.001</td>
<td>1.450±0.001</td>
<td>1.590±0.002</td>
<td>0.551±0.001</td>
</tr>
<tr>
<td>SYM</td>
<td>0.067±0.006</td>
<td>1.300±0.058</td>
<td>1.750±0.058</td>
<td>0.920±0.001</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations. Similar superscript along columns are not significantly different (p>0.05)

Key: UWM: Unsprouted white maize, SWM: Sprouted white maize, UYM: Unsprouted yellow maize, SYM: Sprouted yellow maize.

The raw flour had a higher bulk density than the sprouted one. This could be because sprouting tend to soften the seeds, thus making milling easier, with smaller particle sizes than unsprouted grain, hence the reduction in bulk density. The significance of this is that the less bulky flours will have higher nutrient density, since more flour can be packaged in the same given volume. The raw flour also had a higher swelling index than that of sprouted flour. This could be as a result of the swelling of the starch granules, which leads to disruption of some of the intermolecular hydrogen bonds, thus allowing more water to enter and enlarge the granules (Ikekoronye and Ngoddy, 1985). The sprouted flour, whose starches had already been dextrinized, could not swell as much. Swelling capacity can be an index of stickiness of the resultant product.

There was an increase in both water and oil absorption capacity with sprouted flour taking up more water and oil. This increased solubility could be as a result of the increase in amount of soluble sugars present in the sprouted flour. Flours with better water absorption capacity are easier to reconstitute in water when needed. Eneche (2009) also reported an increase in water absorption with soaking of maize grains. Oil absorption capacity is important since oil acts as flavor retainer and increases the palatability of foods (Kinsella, 1976).

MINERAL COMPOSITION

The values of mineral composition of raw and sprouted white and yellow sweet maize flour are shown in table 3.

Table 3: Mineral Composition (mg/100g) of raw and sprouted yellow and white sweet maize

<table>
<thead>
<tr>
<th>Samples</th>
<th>Iron (mg/100g)</th>
<th>Sodium (mg/100g)</th>
<th>Potassium (mg/100g)</th>
<th>Calcium (mg/100g)</th>
<th>Magnesium (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UWM</td>
<td>0.180±0.006</td>
<td>10.42±0.237</td>
<td>113.70±0.305</td>
<td>0.150±0.065</td>
<td>24.12±0.069</td>
</tr>
<tr>
<td>SWM</td>
<td>0.210±0.004</td>
<td>11.56±0.127</td>
<td>132.00±0.035</td>
<td>0.360±0.127</td>
<td>27.11±0.064</td>
</tr>
<tr>
<td>UYM</td>
<td>0.190±0.058</td>
<td>10.44±0.127</td>
<td>114.01±0.006</td>
<td>0.210±0.064</td>
<td>24.13±0.075</td>
</tr>
<tr>
<td>SYM</td>
<td>0.270±0.635</td>
<td>11.65±0.191</td>
<td>134.70±0.310</td>
<td>0.350±0.069</td>
<td>28.01±0.006</td>
</tr>
</tbody>
</table>

Values are means of triplicate determinations. Similar superscripts along columns are not significantly different (p>0.05)
The mineral contents of the sprouted seeds flour were comparatively higher than that of raw seeds flour. This corroborated with earlier report by Inyang and Zakari (2008). The desirable changes in the nutrient contents may be due to the breakdown of complex compounds into simpler forms. The metabolic activity of resting seeds increases as soon as they are hydrated during soaking. Complex biochemical changes occur during hydration and subsequent sprouting. The reserved chemical constituents are broken down by enzymes into simple components that are used to make new compounds. In general, both raw and sprouted yellow sweet maize tend to be richer in minerals than the white one.

CONCLUSION
This study concluded that germination of both white and yellow sweet maize resulted in the enhancement of its nutritional quality as observed by the significant increase in quantity of protein, reduced bulk and increased nutrient density. These observations could be advantageously utilized to improve nutrition of infant and children foods, particularly in the developing countries, where maize is consumed in large quantity as well as for food products development in food industry. The associated reduction in carbohydrate and fat can be compensated for by blending with flours of other legumes/oil seeds.

REFERENCES


Eneche HE. 2009. Rate of water absorption in maize grains during soaking. Proceedings of the AGM/conference (AGMC’ 09), Nigerian Institute of Food Science and Technology, Yola, pp 41-42.


