EFFECT OF PROCESSING ON THE PHYSICO-CHEMICAL PARAMETERS AND PROXIMATE COMPOSITION OF QUALITY PROTEIN MAIZE FLOUR

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ABSTRACT

The purpose of the study (2022) is to compare QPM maize flour's physico-chemical composition before and after processing. A bag of 12 kg of QPM of the Shaktiman-5 variety was purchased. The gathered maize grains were cleaned by sifting out any remaining foreign material and sick or damaged seeds. In case of processing, the remaining 10 kg of maize grains were split into four equal sets in duplicate. There were 2.5 kg of corn grains in each replica. One set was preserved as the control (in triplicate) out of the four sets (in triplicate) for the study. In case of processing, the other three sets (each in triplicate) were retained. Boiling, roasting, and processing with alkali were the processing techniques used. The highest percentage of moisture content was found in the QPM control samples (13.06%), followed by samples of boiled maize (8.21%), alkali-treated samples (4.80%), and samples that had been roasted (3.65%). In terms of fat, it was discovered that roasted samples (3.92%) had the highest concentration, followed by alkali-treated maize samples (3.40%), boiling samples (3.28%), and control samples (3.23%). Ash level was highest in roasted samples (1.25%), then boiling samples (1.24%), untreated samples (1.14%), and samples treated with alkali (0.93%). The control samples had the highest percentage of fibre content (3.87%), followed by samples of boiled maize (3.79%), alkali-treated samples (3.30%), and samples that had been roasted (2.64%). Alkali treated sample had the greatest protein content percentage (10.85%), followed by control maize. In terms of carbohydrates, roasted samples (77.77%), alkali-treated samples (76.72%), boiling samples (73.13%), and control samples (67.87%) showed the highest amount. While it dropped in alkali-treated maize samples (18.42%), the proportion of ash concentration increased in boiled (8.77%) and roasted (9.65%) samples. After processing the QPM of the Shaktiman-5 variety, there were unquestionably both qualitative and quantitative modifications.

Keywords: Nutrition, Physico-Chemical, Processing, Proximate composition, Shaktiman-5 variety QPM
**INRODUCTION**

The most fundamental human requirement is food. Individual health and nutritional well-being are essential for community growth. Malnutrition is a significant issue on a global scale. Today, micronutrient deficiency is a major concern. A significant public health risk is micronutrient deficiency. In India, micronutrient deficiencies affect more than 80% of the population, which lowers immunity. (Brown *et al.*, 2020)

Malnutrition, also known as malnourishment, is a condition brought on by consuming a diet that is either deficient in nutrients or excessively rich in them, leading to health issues. Malnutrition can also result from a deficiency in minerals. It occurs when our body does not receive enough nutrients in the form of carbohydrates, proteins, lipids, and vitamins. Micro minerals are those found in the human body at concentrations lower than 0.05 percent. Trace elements are also present in the microminerals. Chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, and zinc are some of these trace elements. Zinc is one of these significant trace minerals. Micronutrient deficiencies affect more than 80% of Indians, which can lead to poor health immunity. (Chauhan *et al.*, 2021)

More than a billion people consume maize on a daily basis, both in its entire form and in various processed forms. The nutritional profile of products made from maize is altered by various processing techniques, which has a significant impact on the population that relies on this crop for a significant amount of their caloric demands. Processing techniques that lower phytic acids, including as soaking, fermenting, boiling, and nixtamalization, can increase the bioavailability of minerals. Changes in processing techniques and promoting the consumption of whole-grain maize products versus degemered, refined goods can reduce the loss of micronutrients during processing. (Akinlolu *et al.*, 2014)

The nutritional value of cereals is primarily determined by their chemical make-up and the presence of anti-nutritional elements like phytic acid. Phytates can be found in whole grain cereals, lentils, and other plants in trace amounts. They have a high affinity for binding divalent cations, and human tests have shown that they inhibit the absorption of zinc. (Sandstorm, 2019).

Around the world, maize is a significant cereal crop for both human nourishment and animal feed. Maize has earned a well-deserved reputation as a nutritional cereal thanks to its high concentration of carbohydrates, lipids, proteins, and several crucial vitamins and minerals. Maize is the source of protein and calories for several million individuals, mostly in poor nations. (Prasanna, *et al.*, 2018).

A total of 14.9% moisture, 11.1% protein, 3.6% fat, 2.7% fibre, 66.2% carbs, and 1.5% mineral matter made up maize’s composition. Zinc makes up 2.8 mg/100 g of the total mineral matter, the majority of which is located in the germ. Additionally, maize contains 1 g of phytic acid per 100 grammes concentrated in the germ, which binds to zinc and produces insoluble complexes that lower zinc’s bioavailability. By lowering the amount of phytic acid in the maize, the zinc can be made more bioavailable. This can be accomplished both by processing and by adding phytase enzyme, which aids in hydrolyzing phytate to reduce Inositol phosphates and boost zinc absorption. (Kayode, 2018).

The balanced amino acid makeup of the Quality Protein Maize variety has increased the protein quality. The term “Quality Protein Maize” (QPM) refers to a form of maize with
greater nutritional and biological value that is practically identical to regular maize in terms of cultivation and kernel phenotype. For individuals who rely on maize for their energy, protein, and other nutrient needs, the nutritional advantages of QPM are in fact rather substantial. Other nutritional advantages of QPM include better calcium absorption, higher glucose and carotene utilisation, and higher niacin availability due to higher tryptophan and lower leucine concentration. Furthermore, the quality or acceptability of high protein maize can be preserved while being converted into consumable goods.

MATERIALS AND METHODS

In the year 2022, the study was carried out in the labs of the College of Community Science, OUAT, Bhubaneswar. The goal of the study was to process maize to make flour and determine its proximate composition and physico-chemical characteristics. The methods and means of achieving the objectives have been categorised under various headings:

Selection of raw materials

The most prevalent normal QPM maize variety that is grown and well-liked by consumers of maize (Shaktiman-5 variety) was chosen for the investigation.

Procurement and processing of raw materials

Grain from the farmer’s field that had just been harvested was of the QPM variety. A total of 10 kg of QPM variety maize grains were required for the study. To get rid of dust and other undesired elements, the grains were cleansed thoroughly.

The cleaned maize grains were separated into 4 lots, with one lot serving as the “control” and the other 3 lots being processed by roasting, boiling, and lime treatment. For the investigation, each batch was further divided into 5 equal sections. There was therefore 20 parts made from QPM maize. Fourty parts in total were available for conducting the analytical work.

Analysis of maize grains for physico-chemical parameters

A precision balance was used to measure 100 grains weight of wheat and maize. Grain volume was calculated using the displacement method. The mass/volume method was used to determine the density of grains.

Determination of proximate composition

The hot air oven method was used to determine the moisture content. The conventional method of analysis was used to estimate the amount of ash. (AOAC, 2000.). The amount of crude fibre was calculated using a common analytical technique. (AOAC, 2000.). By calculating the product’s total nitrogen content using the Micro-Kjeldhal Method, crude protein was estimated. (AOAC, 2000.). Using the accepted method and procedure, the fat was determined. (AOAC, 2000.). The quantity of total carbohydrate content is generally represented by the number that results from deducting the sum of the percentages of moisture, fat, ash, crude fibre, and crude protein from 100. (AOAC, 2000.).

Comparative efficacy of different parameters in maize

Standard statistical techniques like Mean, Standard Deviation, and Paired ‘t’ test were used to evaluate the parameters’ comparative efficacy.
Collection QPM grains in one lot (QPM maize- Shaktiman 5) for Processing (Divided into 4 sets)

Set A (triplicate)
- Maize grains
  - Sun dried
  - Control maize sample
    - Flour (triplicate)

Set B (triplicate)
- Maize grains
  - 1. Steeped in double amount of water by weight for 10-15 minutes.
    Boiled in water for 30 minutes. Oven dried for 10 h at 60 °C.
  - Boiled maize sample
    - Flour (triplicate)

Set C (triplicate)
- Maize grains
  - Roasted at 180°C for 20 min.
  - Roasted maize sample
    - Flour (triplicate)

Set D (triplicate)
- Maize grains
  - 1. Soaked for 5 minutes in lime water (1%).
  - 2. Heat treatment was given for 30 minutes at 85°C and it was left over night.
  - 3. It was washed 3-4 times and oven dried for 10 h at 60°C.
  - Alkali treated maize sample
    - Flour (triplicate)

Fig. 1. Preparation of QPM maize grains and flour sample
TABLE 1. Physico-chemical parameters of freshly harvested QPM grains

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameters</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Weight (gm)</td>
<td>32.21 ± 0.77</td>
</tr>
<tr>
<td>2.</td>
<td>Volume (cc)</td>
<td>25</td>
</tr>
<tr>
<td>3.</td>
<td>Density (g/cc)</td>
<td>1.61 ± 0.03</td>
</tr>
</tbody>
</table>

Each value is the mean of six observations.

RESULTS AND DISCUSSION

**Physico-chemical parameters of freshly harvested QPM grains**

Freshly harvested QPM grains’ physico-chemical characteristics Weight, volume, and density measurements of the product were taken in order to evaluate the physico-chemical qualities of QPM maize grains. The gathered information is shown in Table 1 and graphically represented in Fig. 2. Freshly harvested QPM maize grains’ weight was determined to be 32.21 ± 0.77 g, while their volume was measured at 25 cc. 1.61 ± 0.03 g/cc was the density.

**Proximate composition of freshly harvested QPM flour before and after processing**

It was discovered what the proximate composition of QPM flour (control and processed) was. Moisture, fat, ash, fibre, protein, and carbohydrates were the components of the proximate composition. Tables 2 and 3 and Fig. 3 provide data on the nutritional quality of flour and quantitative changes in nutritional quality following application of various processing techniques.

Table 2 shows the approximate composition of QPM flour made from recently harvested QPM grains before and after processes like boiling, roasting, and alkali processing. The control sample was taken from the raw, recently harvested maize grains. The other samples consisted of alkali-treated, roasted, and boiled maize grains. According to Table 2, the control flour sample had 67.87 percent carbohydrates, 10.83 percent protein, 3.23 percent fat, 3.87 percent fibre, and 1.14 percent ash. The percentages of moisture, fat, ash, fibre, protein, and carbohydrates in a sample of boiled maize flour were 8.21, 3.28, 1.24, 3.79, 10.35, and 73.13, respectively. A total of 3.65 percent moisture, 3.92 percent fat, 1.25 percent ash, 2.64 percent fibre, 10.77 percent protein, and 77.77 percent carbohydrates made up the sample of roasted maize flour. The percentages of moisture, fat, ash, fibre, protein, and carbohydrates in a sample of alkali-treated maize flour were 4.80, 3.40, 0.93, 3.30, 10.85, and 76.72, respectively.

According to Sefa-Dedeh et al. (2004), nixtamalization of the maize enhanced the pH, lipid content, moisture content, water absorption capacity, and yellowing of the end products. The protein content of the nixtamalized maize products was enhanced by alkaline cooking.

Table 2 shows that the control samples had the highest percentage of moisture content (13.06%), followed by the boiled maize sample (8.21%), the alkali-treated sample (4.80%), and the roasted sample (3.65%). Thirteen percent moisture content is regarded as a safe level. As a result, the moisture content in the control sample was close to the safe range, or 13%.

The mechanical drying of the maize sample was the cause of the reduced moisture
content in the boiled and alkali treated corn sample. The loss of moisture owing to the application of heat in the case of roasting was the cause of the lowest moisture content (3.65%). In terms of fat, it was discovered that roasted samples (3.92%) had the highest concentration, followed by alkali-treated maize samples (3.40%), boiling samples (3.28%), and control samples (3.23%). Ash level was highest in roasted samples (1.25%), then boiling samples (1.24%), untreated samples (1.14%), and samples treated with alkali (0.93%). The control samples had the highest percentage of fibre content (3.87%), followed by samples of boiled maize (3.79%), alkali-treated samples (3.30%), and samples that had been roasted (2.64%).

The alkali treated sample had the highest proportion of protein (10.85%), followed by the control maize sample (10.83%), the roasted sample (10.77%), and the boiled sample (10.35%). In terms of carbohydrates, roasted samples (77.77%), alkali-treated samples (76.72%), boiling samples (73.13%), and control samples (67.87%) showed the highest amounts.

At the 1% level of probability, the statistical analysis clearly demonstrated that the moisture content of the control maize samples was higher than that of the boiling, roasted, and alkali-treated samples (‘t’ values of 7.006, 9.274, and 9.916, respectively). Additionally, at the 0.1% level of significance, the moisture content of boiled maize samples was higher than that of alkali-treated maize samples (‘t’ value -2.944 and 6.346, respectively) in the control samples. Each value is the mean of six observations; NS Not significant; *Significant at 5% level of probability; **Significant at 1% level of probability

According to Ayatse et al. (1983), heat processing—such as roasting, nixtamalization, extrusion, boiling, baking, or microwaving—improves the colour, texture, flavour, and nutritional value of food products when done under the right conditions.

No discernible change was seen between the control and boiling maize samples in terms of fat. But significant difference at 1% level of probability can be observed between control and roasted maize samples (‘t’ value -25.02), control and alkali treated maize samples (‘t’ value -7.164), boiled and roasted samples (‘t’ value -25.66) and roasted and alkali treated maize samples (‘t’ value 39.401), whereas, the difference between fat content of boiled and alkali treated maize samples (‘t’ value -3.585) was found to be significant at 5% level of probability.

The difference in ash content between the control and boiled samples was not statistically significant, although it was considerably different from the roasted and alkali-treated maize samples (‘t’ values of -2.944 and 6.346, respectively) in the control samples. The ash content of boiled maize samples was higher than that of alkali-treated maize samples (‘t’ value 25.802 at 1% level of significance), but the difference between ash content of roasted and boiled maize samples was determined to be non-significant. Roasted and alkali treated maize samples showed a significant difference at the 1% level of probability (‘t’ value 23.833).

When comparing control and roasted maize samples for fibre, a significant difference (‘t’ value of 5.137) was found at the 1% level of probability. The ash content of the control maize samples did not differ significantly from the boiled maize samples or the alkali-treated maize samples. At the 1% level of significance, the fibre content of the boiling maize samples
Table 2. Proximate composition of QPM flour from freshly harvested maize grains before and after processing.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Maize grain</th>
<th>Parameters (g/100 g)</th>
<th>Sample (Mean±S.D)</th>
<th>Moisture (Mean±S.D)</th>
<th>Fat (Mean±S.D)</th>
<th>Ash (Mean±S.D)</th>
<th>Fibre (Mean±S.D)</th>
<th>Protein (Mean±S.D)</th>
<th>Carbohydrate (Mean±S.D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Control (A)</td>
<td></td>
<td>13.06±2.39</td>
<td>3.23±1.232</td>
<td>1.14±0.437</td>
<td>3.87±1.566</td>
<td>10.83±0.260</td>
<td>67.87±2.738</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Boiled (B)</td>
<td></td>
<td>8.21±3.195</td>
<td>3.28±1.229</td>
<td>1.24±0.015</td>
<td>3.79±0.094</td>
<td>10.35±0.405</td>
<td>73.13±0.839</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Roasted (C)</td>
<td></td>
<td>3.65±0.292</td>
<td>3.92±0.032</td>
<td>1.25±0.027</td>
<td>2.64±0.060</td>
<td>10.77±0.236</td>
<td>77.77±0.446</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Alkali treated (D)</td>
<td></td>
<td>4.80±0.465</td>
<td>3.40±0.042</td>
<td>0.93±0.013</td>
<td>3.30±0.083</td>
<td>10.85±0.286</td>
<td>76.72±0.267</td>
<td></td>
</tr>
</tbody>
</table>

't' value among maize samples

1. A×B  
   7.006** (-) 1.219NS (-) 2.501NS 0.333NS 2.903* (-) 5.990**

2. A×C  
   9.274** (-) 25.02** (-) 2.944* 5.137** 0.778NS (-) 8.331**

3. A×D  
   9.916** (-) 7.164** 6.346** 2.206NS (-) 0.275NS (-) 8.340**

4. B×C  
   12.715** (-) 25.66** (-) 0.439NS 25.214** (-) 2.094NS (-) 10.26**

5. B×D  
   19.145** (-) 3.585* 25.802** 10.144** (-) 4.797** (-) 13.82**

6. C×D  
   (-) 5.974** 39.401** 23.833** (-) 12.68** (-) 0.595NS 4.362**
was higher than that of the roasted maize samples (‘t’ value 25.214) and the alkali-treated maize samples (‘t’ value 10.144). At 1% level of significance, the fibre content of the roasted maize samples was substantially lower than that of the alkali-treated samples (‘t’ value: -12.68).

In terms of protein content, boiled maize samples and control samples showed a significant difference (‘t’ value 2.903) at the 5% level of probability, whereas the difference between boiled maize samples and alkali-treated samples showed a significant difference (‘t’ value -4.797) at the 1% level of probability. Although the protein level in the roasted maize samples was lower than it was in the control samples, the difference was not substantial. Similar to the protein content, the difference between alkali-treated and control maize samples was not statistically significant. Once more, the difference in protein content between roasted and boiling maize samples and between alkali-treated maize samples and roasted maize samples.

All the maize samples had increased carbohydrate content after processing, but the increase in boiled maize samples was significant at 1% level of probability (‘t’ value -5.990), whereas the carbohydrate content of control maize samples was significantly lower than that of roasted maize samples (‘t’ value -8.331) and alkali treated maize samples (‘t’ value -8.340).

At 1% level of significance, the carbohydrate content of the boiling maize samples was lower than that of the roasted maize samples (‘t’ value -10.26) and the alkali-treated maize samples (‘t’ value -13.82). On the other hand, at the 1% level of probability, the carbohydrate content of the roasted maize samples was substantially larger than that of the alkali-treated maize samples (‘t’ value 4.362).

Changes in proximate composition of QPM flour after processing as compared to control sample

Table 3 and Fig. 2 show the variations in the proximate composition of QPM flour following the application of various processing techniques in comparison to the control sample. The largest percentage loss in moisture content was 72.05 percent in the case of the roasted sample, followed by 63.24 percent in the alkali treated sample and 37.13 percent in the boiling sample, as the moisture content was lost in grains acquired after

<table>
<thead>
<tr>
<th>Parameter (g/100g)</th>
<th>Boiled (B)</th>
<th>Roasted (C)</th>
<th>Alkali treated (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>37.13</td>
<td>72.05</td>
<td>63.24</td>
</tr>
<tr>
<td>Fat</td>
<td>1.58</td>
<td>21.36</td>
<td>5.26</td>
</tr>
<tr>
<td>Ash</td>
<td>8.77</td>
<td>9.65</td>
<td>18.42</td>
</tr>
<tr>
<td>Fibre</td>
<td>2.06</td>
<td>31.78</td>
<td>14.72</td>
</tr>
<tr>
<td>Protein</td>
<td>4.43</td>
<td>0.55</td>
<td>0.18</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>7.75</td>
<td>14.59</td>
<td>13.04</td>
</tr>
</tbody>
</table>

Note: Indicates decreasing trend
Figure 2. Physico-chemical parameters of freshly harvested QPM grains

Figure 3. Changes in proximate composition in QPM flour after processing as compared to control sample
processing either due to mechanical drying or roasting.

In all three treated samples, the level of fat increased. Roasted maize samples (21.36%) showed the greatest increase in fat content, followed by alkali-treated samples (5.26%) and boiling samples (1.58%). The ash concentration increased in samples of roasted and boiling corn by 9.65 and 8.77 percent, respectively, whereas, it dropped in samples of alkali-treated maize by 18.42 percent. All three of the treated samples showed a decrease in the level of fibre. Samples of roasted maize showed the greatest drop in fibre content (31.78%), followed by samples of alkali-treated maize (14.72%) and samples of boiling maize (2.06%). Boiling and roasting samples both resulted in a 4.43 percent and 0.55 percent drop in the protein level, respectively. In contrast, it went up by 0.18 percent in samples of alkali-treated corn. All of the maize samples showed an increase in carbohydrate content. Carbohydrate content increased by the most in roasted samples (by 14.59%), alkali-treated samples (by 13.04%), and boiling samples (by 7.75%).

From Tables 2 and 3 & Figure 3, it can be inferred that aside from boiling, the changes in protein content were not substantial. The protein content of samples of boiling maize was substantially lower. Contrarily, following processing, the carbohydrate content rose. While the fibre level in the roasted maize samples decreased, the ash content was dramatically reduced after roasting and alkali treatment. After boiling and roasting, the fat content considerably rose. After processing, there are certainly changes in both quality and quantity.

CONCLUSIONS

Boiled, roasted, and alkali treated QPM of Shaktiman-5 variety maize grain samples showed a change in proximate composition in processed maize grains. In case of samples of boiling, roasted, and alkali-treated maize, respectively, the percentages of moisture and fibre content fell by 37.13 and 2.06, 72.05 and 31.78, and 63.24 and 14.72, while the percentages of fat and carbohydrate increased by 1.58 and 7.75, 21.36 and 14.59, and 5.26 and 13.04, respectively. While it dropped in alkali-treated maize samples (18.42%), the proportion of ash concentration increased in boiled (8.77%) and roasted (9.65%) samples. Alkali-treated samples of maize had a higher percentage of protein (0.18%), but samples of the grain that had been boiled (4.43%) and then roasted (0.55%) had a lower percentage of protein.

With the exception of boiling, processing did not significantly alter the protein content. The protein content of samples of boiling maize was substantially lower. Contrarily, following processing, the carbohydrate content rose. While the fibre level in the roasted maize samples decreased, the ash content was dramatically reduced after roasting and alkali treatment. After boiling and roasting, the fat content considerably rose. After processing, there are certainly changes in both quality and quantity.

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