Mineral Quantitation of Irish Potato (Solanum tuberosum) Treated with Maca (Lepidium meyenii) During Storage

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ABSTRACT

Irish potato (Solanum tuberosum) has contributed to human diet for thousands of years, first in the Andes of South America and then in the rest of the world. Potato is rich in potassium which reduces the risk of cardiovascular disease. Maca (Lepidium meyenii) contains macamides which are thought to have antioxidant effects. Prolonged storage of Irish potatoes is the stage at which good quality tubers are most difficult to maintain because of the transformations occurring at that time lead to quantitative changes in the composition of tubers. This work was designed to quantify potassium along aside with some minerals in Irish potato during storage with aqueous solution of maca flour. In the storage process, potatoes are affected by two negative factors, i.e., high (room) temperature, light and physiological activities in the tuber. The values obtained for Irish potato treated with aqueous maca 1:10 mL distilled water (MA1) and untreated potato as control (CTRL) respectively are potassium (173.85 and 93.67 mg/100 g), sodium (99.74 and 39.59 mg/100 g), magnesium (14.20 and 12.37 mg/100 g), phosphorus (56.00 and 39.00 mg/100 g), zinc (0.34 and 0.30 mg/100 g), manganese (0.39 and 0.33 mg/100 g) and copper (0.01 and 0.01 mg/100 g). MA1 differs significantly (p < 0.05) from CTRL for potassium, sodium, magnesium, phosphorus and zinc while there was no significant difference for manganese and copper. These results indicate that treating potato with low concentration of aqueous maca helps to retain minerals composition during storage.

Keywords: Maca, Irish potato, Storage, Minerals

INTRODUCTION

Potato (Solanum tuberosum L), commonly called Irish potato in Nigeria, possibly because it was introduced by the Irish (Nwokocha et al., 2014), belongs to the solanaceae family and is one of the four most important food crops in the world, along with maize, wheat, and rice. In addition to the nutritionally relevant metabolites, like carbohydrates and vitamins, such as vitamin C or B₆, The mean mineral content of 100 g of Irish potato tuber with a standard deviation was reported by True et al. (1978) as copper (0.290 ± 0.111 mg/100 g), magnesium (31.29 ± 4.66 mg/100 g), manganese (0.380 ± 0.201 mg/100 g), phosphorus (71.84 ± 16.65 mg/100 g), potassium (0.8462 ± 0.392 mg/100 g), sodium (11.56 ± 6.93 mg/100 g) and zinc (0.614 ± 0.117 mg/100 g) (True et al., 1978).

Potassium, calcium and magnesium are especially valuable elements in potato tubers, but their consumption also covers some of the organism’s demand for phosphorus, iodine, and copper. Calcium is present in minor quantities in potatoes ranging
from 2 to 20 mg/100 g contributing not more than 2% of the EAR of calcium for adults (800–1100 mg) per day (Burgos, et al., 2020). Prolonged storage of potatoes is the stage at which good quality tubers are most difficult to maintain because the transformations occurring at that time lead to quantitative and qualitative changes in the composition of tubers (Wierzbowskar et al., 2016).

Maca (*Lepidium meyenii* W) is called Peruvian ginseng in English, ‘Gadali’ and ‘Albasan tamoji’ in Hausa, and ‘Isu baca’ in Yoruba. Maca belongs to the Brevicaceae family and is a root native to the Andean region of Peru, cultivated for at least 2000 years BC (Natalia et al., 2020). Maca grown in Xinjiang China contains mainly three elements, including calcium (13700.00 ± 282.80 ug/1 g), magnesium (847.50 ± 15.30 ug/1 g), and zinc (30.70 ± 0.80 ug/1 g). Others are iron (82.40 ± 08 ug/1 g), copper (5.90 ± 0.60 ug/1 g), manganese (11.20 ± 0.60 ug/1 g), potassium (11700 ± 141.40 ug/1 g), and sodium (188.00 ± 24.90 ug/1 g) (Jiaying et al., 2017).

**MATERIALS AND METHODS**

**Preparation of Maca Flour**

Maca flour was prepared from the maca tuber and analyzed for minerals (sodium, zinc, manganese, magnesium, phosphorus, and potassium). The 1: 10 aqueous coat of maca was prepared according to Tomitope et al., (2022) method, and applied to the Irish potato by dipping. The above minerals were quantified using the graphite method of AOAC 2012 on days 1, 8, 15, and 22 of storage. Results were subjected to statistical analysis using SPSS version 26 post hoc Duncan test for homogeneity of variance.

**Collection of Maca and Irish Potatoes**

Fresh Maca (*Lepidium meyenii*) was obtained from the local farmers in Baram Gada an outskirt of the Bauchi Local Government Area, Bauchi State by the method adopted by Suzanne (2010) for plant sample collection; which involves the manual collection by human hand and simple farm instrument (hoe) (Suzanne 2010). The samples were transported to the Chemistry Laboratory where they were processed into flour and analyzed for minerals using graphite method for mineral determination by AOAC (2012).

**Processing of Maca Flour**

Maca root tubers were cleaned, graded, and spread to dryness in a ventilated room for three weeks. The dried samples were pulverized with a pulverizer and sieved to obtain fine flour. The flour was packaged in a plastic container (Sedano et al., 2017). The packaged maca sample was transported to the Chemistry Postgraduate Research Laboratory of Benue State University Makurdi for analysis of minerals in October 2023.

![Figure 1: Process flow chart of maca flour](source: Sedano et al., 2017.)
The formulation was done according to the method suggested by Tomitope et al. (2022) in which 0 g, and 10 g of Maca flour were dissolved into 10 mL of water to give 0:10 and 10:10 (wt./v) concentration. The resultant mixture was set on low heat (40°C) for 15 min. The solutions were left to cool to room temperature. The samples represented as CTRL (Irish potato dip coated in 0 g of Maca flour dissolved in 10 mL of distilled water) and MA1 (Irish potato dip coated in 1 g of Maca flour dissolved in 10 mL of distilled water) (Tomitope et al., 2022).

The samples were stored for mineral quantitation under room conditions at Bauchi – Nigeria with an average relative humidity (RH) of 43% and an average temperature of 77°F between March and April 2023. Analytical samples were prepared at intervals of seven days starting from 20th March, 27th March, 3rd April, and 10th April 2023, and transported to the Chemistry Laboratory of Benue State University Makurdi for analysis.

Analyses of Minerals

The graphite method for mineral determination by AOAC (2012) was used to determine potassium, magnesium, phosphorus, zinc, copper, manganese, and sodium in treated and untreated Irish potato samples. 10 mL of concentrated nitric acid was added to the ash obtained after ashing an oven at 550°C, and 1 mL of perchloric acid was added to the solution and heated at 100°C for digestion in a fume cup until the solution was cleared. A 10 mL of distilled water was added, filtered into a 50 mL volumetric flask, and filled to mark with distilled water. Absorbance was taken with a spectrophotometer using lamps for potassium, magnesium, phosphorus, zinc, copper, manganese, and sodium. An equation of a straight-line graph obtained from a standard calibration curve was used to calculate the concentration of the metals present (AOAC, 2012).

Data Analysis

All numerical data generated were subjected to Analysis of Variance (ANOVA). SPSS version 25 statistical package software was used for statistical analysis (Rajan, 2021).

RESULTS

Mineral Composition of Maca

The mineral composition of freshly harvested maca root tuber for sodium, zinc, magnesium, manganese, copper, phosphorus, and potassium is shown in Table 1.

Mineral Composition in Treated and Untreated Irish Potato

The result for the composition of sodium, zinc, magnesium, manganese, copper, phosphorus, and potassium present in maca-treated and untreated Irish potatoes during the storage period is presented in Table 2.

**Table 1: Mineral Composition of Maca (mg/100 g)**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Zn</th>
<th>P</th>
<th>Cu</th>
<th>Mn</th>
<th>K</th>
<th>Na</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maca</td>
<td>0.35±0.00</td>
<td>0.25±0.00</td>
<td>0.01±0.00</td>
<td>0.27±0.00</td>
<td>83.76±0.00</td>
<td>25.57±0.00</td>
<td>12.43±0.00</td>
</tr>
</tbody>
</table>
Table 2: Mineral composition in treated and untreated Irish potatoes (mg/100g)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Mineral</th>
<th>Storage time (Days)</th>
<th>Total mean score</th>
<th>Total Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>MA1</td>
<td>Sodium</td>
<td>33.93±0.00</td>
<td>26.16±0.00</td>
<td>168.11±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Sodium</td>
<td>33.93±0.00</td>
<td>28.15±0.00</td>
<td>46.16±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Manganese</td>
<td>0.45±0.00</td>
<td>0.46±0.00</td>
<td>0.32±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Manganese</td>
<td>0.45±0.00</td>
<td>0.39±0.00</td>
<td>0.27±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Zinc</td>
<td>0.41±0.00</td>
<td>0.32±0.00</td>
<td>0.31±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Zinc</td>
<td>0.41±0.00</td>
<td>0.32±0.00</td>
<td>0.25±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Magnesium</td>
<td>14.89±0.00</td>
<td>13.99±0.00</td>
<td>13.95±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Magnesium</td>
<td>14.89±0.00</td>
<td>12.55±0.00</td>
<td>11.17±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Copper</td>
<td>0.01±0.00</td>
<td>0.01±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Copper</td>
<td>0.01±0.00</td>
<td>0.01±0.00</td>
<td>0.01±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Phosphorus</td>
<td>61.00±0.00</td>
<td>46.00±0.00</td>
<td>49.00±0.00</td>
</tr>
<tr>
<td>CTRL</td>
<td>Phosphorus</td>
<td>61.00±0.00</td>
<td>35.00±0.00</td>
<td>31.00±0.00</td>
</tr>
<tr>
<td>MA1</td>
<td>Potassium</td>
<td>105.91±0.00</td>
<td>125.47±0.00</td>
<td>231.26±0.00</td>
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<tr>
<td>CTRL</td>
<td>Potassium</td>
<td>105.91±0.00</td>
<td>70.43±0.00</td>
<td>98.57±0.00</td>
</tr>
</tbody>
</table>

Means ± SE in the same raw with different superscript differed significantly (p<0.05)

Key: MA1: Treated Irish potato with Maca flour, CTRL: Control Irish potato sample
DISCUSSION

The quantity of zinc, phosphorus, copper, manganese, potassium, sodium, and magnesium in maca grown in Bauchi Nigeria is shown in Table 1. The concentrations were found to be Zn 35.00 ug/1 g, P 25.00 ug/1 g, Cu 1.00 ug/1 g, Mn 27.00 ug/1 g, Na 255.70 ug/1 g, K 8376.00 ug/1 g and Mg 1243 ug/1 g. The results for Zn, Cu, and Mn are in agreement with the results reported by Jiaying et al., (2017) which are 30.70 ug/1 g, 5.90 ug/1 g, and 11.20 ug/1 g respectively. The results for Mg and Na are higher compared to Jiaying et al (2017) report which is 847.50 ug/1 g and 188.00 ug/1 g respectively. The concentration of K is lower compared to Jiaying’s report of 11700.00 ug/1 g. This variation in the concentrations of the minerals can be attributed to differences in planting environment i.e. Bauchi – Nigeria with an average relative humidity (RH) of 43% and average temperature of 77°F in March – April 2023 compared to Xinjiang – China in 2017 at the time of analysis.

There is a quantitative distinction of mineral composition between MA1 and CTRL in potatoes during the storage studies as presented in Table 2. The raw result shows total mean concentration ± standard deviation (S.D) for Na in MA1 (99.74 ± 0.7286 mg/ 100 g) > CTRL (39.59 ± 0.0929 mg/ 100 g), Mn in MA1 (0.39 ± 0.0650 mg/ 100 g) > CTRL (0.33 ± 0.0450 mg/100 g) > CTRL (0.30 ± 0.0820 mg/100 g), Mg in MA1 (14.20 ± 0.4170 mg/ 100 g) > CTRL (12.37 ± 0.1652 mg/100 g), P in MA1 (56.00 ± 05.6900 mg/100 g) > CTRL (39.00 ± 13.1700 mg/100 g), K in MA1 (173.85 ± 0.6118 mg/ 100 g) > CTRL (93.67 ± 0.1431 mg/100 g) and Cu in MA1 (0.01 ± 0.0021 mg/100 g) = CTRL (0.01 ± 0.0028 mg/ 100 g). This showed a significant difference (P<0.05) between MA1 and CTRL, with MA1 having the highest concentrations in Na, Mn, Zn, Mg, P, K, while a non-significant difference in Cu during the study period and environment. This is evident that Irish potato treated with 1:10 mL aqueous concentration of maca helped to preserve these minerals during storage period under an average RH of 43% and average temperature of 77°F.

Copper content was found to be 0.01 mg/100 g in both samples recorded in this study; this value is lower compared to the value reported by True et al. (0.38 mg/100 g) in United States. Copper is an essential mineral for bone strength, hearth health, immune system and much more, as an essential mineral the body needs it to function properly and stay healthy (Lefton & Harries, 2024). MA1 and CTRL provide 1.11 % of reference daily intake (0.9 mg) provided by the United States Food and Drug Administration (US FDA) (2016), while providing 1.72%.

The value of magnesium (14.20 ±0.4170 mg/ 100 g for MA1 and 12.37 ± 0.1652 mg/100 g for CTRL) is lower than (31.29 & 23.00 mg/100g) was reported by True et al. (1978) and Sharad cultivated in United States and China respectively. This difference may be attributed to differences in nutrient uptake, planting environment, and agricultural practice. Magnesium plays an important role in assisting more than 300 enzymes to carry out various chemical reactions in the body, such as building proteins and strong bones and regulating blood pressure, muscles, and nerve functions (Chan, 2024). MA1 provides 3.38 % of reference daily intake (420 mg) provided by the United States Food and Drug Administration (US FDA) (2016), while CTRL provides 2.95%. It can be seen that MA1 is significantly higher in magnesium compared to CTRL. This difference may be attributed to the usage of magnesium in CTRL being higher than MA1 postharvest biochemical activities that lead to degradation of nutritional quality.

Manganese values of 0.39 ± 0.0650 mg/ 100 g for MA1 and 0.33 ± 0.1020 mg/ 100 g for CTRL recorded in this study are in consistent with 0.38 mg/100g reported by True et al. (1978) in the United States. Manganese is a trace mineral that the body needs in small amounts for the normal functioning of the brain, nervous system, and many body’s enzyme systems as cofactors (Goodson, 2024). MA1 provides 16.96 % of reference daily intake (2.3 mg) provided by United States Food and Drug Administration (US FDA) (2016), while CTRL provides 8.67%.

There is agreement in phosphorus values of 56.00 ± 05.69 mg/100 g for MA1 and 39.00 ± 13.17 mg/100 g for CTRL recorded in this study with 0.38 mg/100g reported by True et al. (1978) in the United States. Phosphorus is among the main mineral present in tubers and is a healthy component of bones and teeth, as well as a key component in the brain, muscles, and nerve tracts (Harrington, 2024). MA1 and CTRL provides 1.11 % of reference daily intake (0.9 mg) provided by the United States Food and Drug Administration (US FDA) (2016), while providing 1.72%.
key player for healthy teeth, bones and cells (Wekhe et al. 2023). MA1 provides 4.48 % of reference daily intake (RDI) of 1250 mg provided by the United States Food and Drug Administration (US FDA) (2016), while CTRL provides 3.12 %. Conclusively phosphorus content is more preserved MA1 than CTRL sample and provides more RDI.

Potassium content in MA1 (173.85 ± 0.6118 mg/100 g) is consistent with the quantities reported by Sharad (421.00 mg/100 g) and Wekhe et al., (169.43 mg/100 g), although a lower value was reported by True et al. (1978) (0.8462 mg/100 g) whose reason may be exclusion of potassium in form of inorganic fertilizer because the study was in 1978. The potassium content in CTRL (93.67 ± 0.1431 mg/100 g) has a lower concentration compared to Sharad and Wekhe's values. Potassium is a mineral that is classified as an electrolyte because it is highly reactive when in water, when dissolved in water it produces positively charged ions which conduct electricity. Therefore potassium is important in many processes throughout the body which include the reduction of high blood pressure and water retention, protection against stroke, and prevent osteoporosis and kidney stones (Raman, 2023). MA1 provides 3.70 % of reference daily intake (4700 mg) provided by the United States Food and Drug Administration (US FDA) (2016), while CTRL provides 1.99%.

Results for sodium composition revealed 99.74 ± 0.7286 mg/100 g for MA1 and 39.59 ± 0.0929 mg/100 g for CTRL. Sodium content in MA1 99.74 ± 0.7286 mg/100 g is consistent with the quantities reported by Wekhe (99.97.00 mg/100 g), although a lower value was reported by True et al. (1978) (11.56 mg/100 g) and Sharad (6.00 mg/100 g). Sodium is an electrolyte that carries electric charges when dissolved in water which helps fluid absorption and nutrient transport in the cells. Sodium is an essential mineral that helps to regulate the fluid balance in the body, maintain blood pressure support nerve and muscle function, and play a role in the absorption of nutrients like glucose and amino acids (Mayer & Ball, 2023). MA1 provides 4.34 % of reference daily intake (550 mg) provided by the United States Food and Drug Administration (US FDA) (2016), while CTRL provides 1.72%.

Zinc content in MA1 (0.34 ± 0.0450 mg/100 g) and CTRL (0.30 ± 0.0820 mg/100 g) has lower concentration compared to True et al. (1978) value (0.614 mg/100 g). Zinc is a mineral that plays a big role in maintaining men’s overall health. It’s involved in various body functions like immunity, sexual health, mental health, and wound healing. Getting enough zinc is key to backing up these roles and fending off health issues tied to a lack of zinc (Nayana, 2024).

From the result above, MA1 shows a significantly high (p < 0.05) amount of potassium, phosphorus, sodium, and magnesium while CTRL tends to show a lower amount of these minerals. Manganese and zinc had lower concentrations in both samples with MA1 having significant (p < 0.05) higher concentrations compared to CTRL. The values obtained in this study for copper show no significant difference in both MA1 and CTRL.

CONCLUSION

Conclusively, the results obtained for mineral quantitation in this study prove that minerals can be retained during storage of Irish potato treated with maca flour aqueous solution at 1:10 mL concentration by dipping method.

REFERENCES


