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Research Article

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

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ABSTRACT

Irish potato (*Solanum tuberosum*) has contributed to the 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 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 potatoes during storage with an 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 (0.01and 0.01 mg/100 g). MA1 differs significantly ($p < 0.05$) from CTRL for potassium, sodium and magnesium phosphorus and zinc while there was no significant difference for manganese and copper. These results indicate that treating potatoes with low concentrations of aqueous maca helps to retain mineral composition during storage.

Keywords: Maca, Irish potato, Storage, Minerals

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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 B_6. The mean mineral content of 100 g of Irish potato tuber with a standard deviation was reported by True *et al*. (1978) as (0.290 ± 0.111 mg/100 g) for copper, (31.29 ± 4.66 mg/100 g) for magnesium, (0.380 ± 0.201 mg/100 g) for manganese, (71.84 ± 16.65 mg/100 g) for phosphorus, (0.8462 ± 0.392 mg/100 g) for potassium, (11.56 ± 6.93 mg/100 g) for Sodium and (0.614 ± 0.117 mg/100 g) for zinc, (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 estimated average requirement (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*) is called Peruvian ginseng in English, 'Gadali' and 'Albasan tamoji' in Hausa, and 'Isu baca' in Yoruba. Maca belongs to the Bracecaceae 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).

Fresh Irish potatoes were obtained from Dandai Mwaghabul village of Panyam district in Mangu local government area of Plateau State by the method adopted by Suzanne, (2010). The samples were transported to Chemistry Laboratory where they were treated with maca flour solution for mineral quantitation during storage period immediately using graphite method for mineral determination by AOAC (2012).

Reagents

Nitric acid and perchloric acid were purchased from chemical vendors from CHY – KELVIN Ventures Markurdi Nigeria (All the chemicals were of analytical grade).

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.

Figure 1: Process flow chart of maca flour Source: Sedano *et al.* (2017)

Formulation of Treatment Solution from Maca Flour

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 respectively to give 0:10 and 1:10 (wt. /v) concentrations. The resultant mixture was set on low heat (40°C) for 15 min. The solutions were left to cool to room temperature. The samples were represented as CTRL for Irish potato dipped in coated solution 0 g of Maca flour dissolved in 10 mL of distilled water) and as MA1 for Irish potato dipped in coated solution

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 Makurdi – Nigeria with an average relative humidity (RH) of 59% and an average temperature of 93^0F 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 in an oven at 550^oC, and 1 mL of perchloric acid was added to the solution and heated at 100°C for digestion in a fume cupboard 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)

Sample	Zn	P	Cu	Mn	K	Na	Mg
Maca	0.35±0.00	0.25 ±0.00	0.01 ± 0.00	0.27 ± 0.00	83.76 ± 0.00	25.57±0.00	12.43± 0.00

Table 2: Mineral composition in treated and untreated Irish potatoes (mg/100g)

Samples	Mineral (mg/100 g)	Storage time (Days)				Total mean score	Total Standard Deviation
		1	8	15	22		
MA1	**Sodium**	$33.93^{c} \pm 0.00$	$26.16^{d} \pm 0.00$	$168.11^{b} \pm 0.00$	$170.78^{a} \pm 0.00$	99.74 ± 0.00	0.7287
CTRL		$33.93^{c} \pm 0.00$	$28.15^{d} \pm 0.00$	$46.16^{b} \pm 0.00$	$50.11^{a} \pm 0.00$	39.59 ± 0.00	0.0929
MA1	**Manganese**	$0.45^{a} \pm 0.00$	$0.46^{a} \pm 0.00$	$0.32^{b} \pm 0.00$	$0.35^{b} \pm 0.00$	0.39 ± 0.00	0.0650
CTRL		$0.45^{a} \pm 0.00$	$0.39^{b} \pm 0.00$	$0.27^{c} \pm 0.00$	$0.20^{d} \pm 0.00$	0.33 ± 0.00	0.1020
MA1	**Zinc**	$0.41^{a} \pm 0.00$	$0.32^{b} \pm 0.00$	$0.31^{c} \pm 0.00$	$0.31^{d} \pm 0.00$	0.34 ± 0.00	0.0450
CTRL		$0.41^{a} \pm 0.00$	$0.32^{b} \pm 0.00$	$0.25^{c} \pm 0.00$	$0.20^{d} \pm 0.00$	0.30 ± 0.00	0.0820
MA1	**Magnesium**	$14.89^{a} \pm 0.00$	$13.99^{b} \pm 0.00$	$13.95^{c} \pm 0.00$	$13.95^{c} \pm 0.00$	14.20 ± 0.00	0.4170
CTRL		$14.89^{a} \pm 0.00$	$12.55^{b} \pm 0.00$	$11.17^{c} \pm 0.00$	$10.89^{d} \pm 0.00$	12.37 ± 0.00	0.0165
MA1	**Copper**	$0.01^{b} \pm 0.00$	$0.01^{d} \pm 0.00$	$0.01^{c} \pm 0.00$	$0.01^{a} \pm 0.00$	0.01 ± 0.00	0.0021
CTRL		$0.01^{a} \pm 0.00$	$0.01^{d} \pm 0.00$	$0.01^{c} \pm 0.00$	$0.01^{b} \pm 0.00$	0.01 ± 0.00	0.0028
MA1	**Phosphorus**	$61.00^{a} \pm 0.00$	$46.00^{d} \pm 0.00$	$49.00^{c} \pm 0.00$	$50.00^{b} \pm 0.00$	56.00 ± 0.00	0.0569
CTRL		$61.00^{a} \pm 0.00$	$35.00^{b} \pm 0.00$	$31.00^{c} \pm 0.00$	$30.00^{d} \pm 0.00$	39.00 ± 0.00	0.0132
MA1	**Potassium**	$105.91^{d} \pm 0.00$	$125.47^{c} \pm 0.00$	$231.26^{b} \pm 0.00$	$232.78^{a} \pm 0.00$	173.85 ± 0.00	0.6118
CTRL		$105.91^{a} \pm 0.00$	$70.43^{d} \pm 0.00$	$98.57^{c} \pm 0.00$	$99.76^{b} \pm 0.00$	93.67 ± 0.00	0.1431

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 59% and average temperature of 93^{O}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 ± 0.1020 mg/ 100 g), Zn in MA1 (0.34 ± 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 (s0.01 **±** 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. 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 relative humidity (RH) of 43% and average temperature of 77^{o}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 (0.38 mg/100 g) reported by True *et al*. (1978) 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) reported by True *et al*. (1978) and Sharad (2008) 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 can provide 3.38 % of reference daily intake (420 mg) based on the report by the United States Food and Drug Administration (US FDA) (2016), while CTRL can provide 2.95%. It can be seen that MA1 is significantly higher in magnesium compared to CTRL.

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/100 g 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 samples provide 16.96 % of reference daily intake (2.3 mg) provided by the 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 True *et al.* (1978) United States, Sharad (2008) China and Wekhe *et al.* (2023) Nigeria whose findings were 71.84 mg/100 g, 57.00 mg/100 g and 26.07± 0.06 mg/100 g respectively. The significant difference between MA1 and CTRL is an evident that some amount of phosphorus may be used in biochemical phosphorylation (Hellmann et al 2021). Phosphorus is among the main mineral present in tubers and is a healthy key player for healthy teeth, bones and cells (Wekhe *et al.* 2023). MA1 can provides 4.48 % of reference daily intake (RDI) of 1250 mg according to report by the United States Food and Drug Administration (US FDA) (2016), while CTRL can provides 3.12 %. Conclusively phosphorus content is more preserved in MA1 than CTRL samples and provides more recommended dietary intake (RDI).

Potassium content in MA1 (173.85 **±** 0.6118 mg/ 100 g) is consistent with the values reported by Sharad

(421.00 mg/100 g) and Wekhe *et al*., (169.43 mg/100 g), although a lower value (0.8462 mg/100 g) was reported by True *et al.* (1978) whose reason was due to exclusion of potassium in the form of inorganic fertilizer because the Irish potato samples used in his study was free of inorganic source of potassium (True *et al.* 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 (99.74 ± 0.7286 mg/ 100 g) in MA1 is consistent with the quantities (99.97.00 mg/100 g) reported by Wekhe, although a lower value (11.56 mg/100 g) was reported by True *et al.* (1978) 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) as recommended by the United States Food and Drug Administration (US FDA) (2016), while CTRL provides 1.72%.

Zinc content (0.34 ± 0.0450 mg/100 g) in MA1 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 an essential element and an important component of more than 200 plant enzymes in which it plays both structural and functional roles (DalCorso *et al, 2014*). Zinc also 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). Based on DalCorso *et al*.'s statement MA1 has more structural and functional roles compared to CTRL.

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.

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