Original Research Article

PROXIMATE AND MINERAL COMPOSITION OF AERIAL POTATO (*DIOSCOREA BULBIFERA* LINN) AFTER USING DIFFERENT FERMENTATION METHODS

ABSTRACT

This study evaluated the nutritional value of aerial yam potato fermented with different methods and other food processing. Aerial potato was subjected to different treatments (peeled, unpeeled, peeled and blanched, unpeeled and blanched, peeled and boiled, unpeeled and boiled) before fermentation with different methods like submerged fermentation and back slope (BS) fermentation. The proximate and mineral compositions were monitored using standard methods.

Crude Protein (%) of the peeled aerial potato significantly increased from 4.12 ±0.13 at the initial to 10.11±0.85 at the end of the fermentation while unpeeled aerial potato slightly increased from 3.66[a]±0.04 at the initial to 4.19±0.03 at the end of the fermentation. Peeled and blanched; unpeeled and blanched as well as the unpeeled and boiled samples had the highest iron (0.143±0.01 ppm), magnesium (6.40±0.02 ppm) and calcium (6.32±0.03 ppm) contents in fermented aerial potato sample. Generally, the different of methods of fermentation employed improved the nutrient contents of fermented aerial potato.

Keywords: Fermentation, aerial potato, nutrient, anti-nutrients

INTRODUCTION

Dioscorea bulbifera is a perennial vine with broad, alternate leaves, and two types of storage organs. The primary means of spread and reproduction are by the bulbils. The smallest bulbils make control of air potato difficult due to their ability to sprout at a very small stage. The vine produces small white flowers; however, these are rarely seen when it grows in Florida. The fruits are capsules (Rayamajhi *et al*., 2021). *Dioscorea bulbifera* is one of the medicinal plants whose genetic resources in the world are getting into extinction due to habitat loss, climate change, overexploitation and poor natural regeneration since it is dioecious and chances of finding a fertile seed are automatically reduced (Ikiriza *et al.*, 2019). *Dioscorea bulbifera* preparation has been used for memory enhancement, anti-aging, constipation and fever, and has also been used as an infusion to apply to cuts and sores due to its high composition of the tannin that is used to hasten healing of wounds in a flamed membrane (Odeghe *et al*, 2020). In Cameroon and Madagascar, the pounded bulbils are applied to abscesses, boils and wound infections. The bulbil of *D.bulbifera* has also been identified to contain saponin steroidal phytochemical called diosgenin that possess anti-fertility activity in addition to many other medicinal uses such as contraceptives, sexual vigour remedy and treatment of piles, dysentery, syphilis, ulcers, tuberculosis, leprosy, cough and diabetes (Kundu *et al.*, 2021). The clinical significance varies greatly depending on the mode of preparation and the administration, hence the need for its conservation (Ikiriza *et al.*, 2019).

Dioscorea bulbifera preparation has been used for memory enhancement, anti-aging, constipation and fever (Odeghe *et al*, 2020), and has also been used as an infusion to apply to cuts and sores due to its high composition of the tannin that is used to hasten healing of wounds in a flamed membrane (Ikiriza *et al.*, 2019). This research is therefore focused on studying the microbial and physicochemical changes during the fermentation and processing of aerial potato (*Dioscorea bulbifera* Linn).

Material and Methods

Proximate and Mineral analysis

Proximate analysis of samples was determined using standard procedures of the Association of Official Analytical Chemist (2005). Moisture, ash, fibre, fat, crude protein and carbohydrate contents were analysed. Determination of minerals was done according to AOAC (2005). The following minerals; sodium, potassium, calcium, magnesium, zinc, copper, manganese, iron, and phosphorus were assayed for. The sample was ashed at 550^{o}C for 5-6 hours. After cooling to room temperature, the ash was dissolved in l ml 0.5% HNO_3. The sample volume was made up to 100ml and the level of mineral present was analyzed by Atomic absorption spectrophotometer Buck 201 VGP. The mineral content was calculated using the formula below;

$$\text{Mineral (mg/g)} = \frac{R \times V \times D}{Wt}$$

Where R = solution concentration

V= volume of sample digest

D= dilution factor and Wt = weight of sample (AOAC, 2005)

Statistical analysis

Data obtained was subjected to one-way analysis of variance (ANOVA). Means were separated with Duncan's New Multiple Range Test (DNMRT) and differences were considered significant at $P \leq 0.05$.

Results and Discussion

Table 1 shows the proximate composition of unpeeled and peeled aerial potato after using different fermentation methods. Crude Protein (%) of the peeled aerial potato significantly increased from 4.12 ±0.13 at the initial to 10.11±0.85 at the end of the fermentation while unpeeled aerial potato slightly increased from 3.66±0.04 at the initial to 4.19±0.03 at the end of the fermentation. Table 2 shows the proximate composition of peeled and unpeeled-blanched aerial potato after using different fermentation methods. Carbohydrates content (%) reduced from 85.59±0.02 - 75.98±0.02 and slightly increased from 77.13±0.13 - 78.99±0.14 at the end of the fermentation for the peeled and unpeeled-blanched aerial potato respectively. Table 3 shows proximate composition of peeled and unpeeled-boiled aerial potato after using different fermentation methods. Moisture content (%) noticeable increased from 6.53^{a}±0.58 to 11.88±0.14 in the peeled-boiled aerial potato and reduced from 15.19±0.41 to 11.95±0.13 unpeeled-boiled aerial potato. Proximate composition is an important criterion to determine the nutrient content and quality of foods (Adejuwon *et al*., 2021). Microorganisms have been used successfully as tools for enhancing the value of agricultural products (Mahesh and Madhu, 2013). Such microorganisms possess the prerequisite enzymes for breakdown of complex polysaccharide components of the agricultural products to sugars. This brings about an increase in the energy value of the materials. Also, specific microorganisms are able, by fermentation, to convert some of the resultant sugars to other required nutrients such as proteins and fats, leading to increases in the values of the nutrients (Keishing *et al*., 2015). The observed increase in the ash content (Table 4 – 6) due to the different fermentation processes may imply increases in the values of some of the elemental components of the substrates. This may be an advantage as it may ensure the availability of adequate minerals required for healthy growth in humans (Abonyi *et al*., 2012).

The proximate composition of all samples revealed carbohydrates content ranged between 72.60 %– 99.40 % (Tables 4 – 6). This result is in accordance with the findings of Ogbuagu (2008) who stated the carbohydrate contents of processed *Dioscorea bulbifera* and *Dioscorea dumentorum* to be within 79.15 % – 83.21 % and 78.82 % – 82.26 % respectively. The dry matter of most root crops is made up of about 60-90% carbohydrate (Ogbuagu, 2008). The values are comparable to the carbohydrate contents of white yam; 78 %, water yam; 75.65 % and sweet potato; 82.55% (Olatoye and Arueya, 2019). This quantity of energy makes aerial potato one of the most carbohydrate rich foods in supplying high quantity of energy per given mass of food consumed (Bolaniran *et al*., 2019).

Samples have high protein contents ranging from 3.50 % – 11.86 % (Tables 4 – 6). The observed increase in protein content was due to bioconversion of simple products of polysaccharide breakdown into protein (Mohite *et al*., 2013). The increased protein content after fermentation indicates its usefulness as requirement for man and animals (Onyimba *et al*., 2015). The protein quantity in the yam suggests that it will serve as a source of amino acids and protein for both man and animal (Rutherford *et al*., 2015). The increase in protein content of fermented unpeeled and peeled aerial potato (Table 4) could be due to the synthesis of amino acids during the fermentation process (Onyimba *et al*., 2015).

Fat content for all samples did not exceed 4.47 % (Tables 4 – 6). This findings can be attributed to the fact that all root crops exhibit low fat content (Keishing *et al*., 2015).The observed increase in fat content could be as a result of conversion of fermentable sugars into fat which could mean an increase in the energy content of the fermented substrate (Mordenti, 2021).

Fibre content of 0.83 % – 0.99 % suggests a possible good bowel movement when consumed. The fibre content in seeds indicates ability to aid digestion and prevent the absorption of excess cholesterol in the body (Mensah *et al*., 2008). The substantial amount of fibre in the samples showed they can be of help in proper functioning of the digestive system (Arawande and Borokini, 2010). Fibre is regarded as essential, as it absorbs water and provides roughage for the bowels, assisting intestinal transit (Ogbuagu, 2008).

The anti-nutrient compositions reduced significantly ($p<0.05$) with fermentation. Reduction of anti-nutrients in fermented samples was due to hydrolysis and degradation of anti-nutrient compounds during fermentation (Maduforo, 2014).

Table 4 shows the mineral composition of unpeeled and peeled aerial potato after using different fermentation methods. Prominent of these effects is the activities of the mixed culture of the peeled and unpeeled samples in which sodium (Na) was reduced for about 50% from 10.99±0.01 to 5.72±0.08. The same pattern was observed for magnesium in which there was reduction of the amount from 11.54±0.05 at the initial to 5.10±0.00 at the end of the fermentation. This same pattern was observed for the other minerals. Table 5 shows mineral composition of peeled and unpeeled blanched aerial potato after using different fermentation methods. All the samples and their various treatments or processing caused a reduction in the amount of minerals at the end (168 hour) of the fermentation but an exception of these effects was seen in the activities of the peeled-blanched and unpeeled-blanched aerial potato in which calcium (Ca) increased from 9.06±0.05 and 7.73±0.03 at the initial to

11.57±0.01 and 9.03±0.06 at the end (168 hour) of the fermentation respectively. Table 6 shows the mineral composition of peeled and unpeeled-boiled aerial potato after using different fermentation methods. There was reduction in the amount of all minerals except for Magnesium (Mg) present in the peeled-boiled aerial potato. Magnesium increased from 9.50±0.01 at the initial to 15.06±0.01 at the end of the fermentation. Minerals are important constituents of human diet as they serve as cofactors for many physiological and metabolic processes (Bolajoko *et al*., 2017). Iron as an essential mineral required for a number of biological functions, including proper functioning of the immune system, electron transfer reactions, gene regulation, cell growth and differentiation as well as binding and transport of oxygen (Siddiqui *et al*., 2014). Iron is also important in the diet of both pregnant and nursing mothers, infants, convalescing patients and the elderly to prevent anemia (Benson *et al*., 2021). Potassium and sodium may reduce the incidence of hypertension as it would not induce high blood pressure, which is the major cause of cardiovascular diseases (Du *et al*., 2014). The presence of calcium implies it could prevent bone diseases and also enhances the effective use of iron in the system (Adeyeye, 2013). Magnesium is required for the action of more than 300 enzymes in the body, where it participates in several significant physiological functions in the maintenance of good health and glucose homeostasis (Bolajoko *et al*., 2017). Magnesium plays a fundamental role in most reactions involving phosphate transfer and is also believed to be essential in the structural stability of nucleic acids and intestinal absorption (Khan, 2014).

The mineral compositions showed that the mineral contents was higher in unfermented than the fermented samples. The fact that the minerals reduced during fermentation is an indication that the microorganisms in the fermenting liquid make use of the minerals. According to Mouquet-River *et al*. (2008), if not for these microorganisms utilizing these minerals, it would have increased. The reduction in the concentration of the minerals in the fermented samples could also be attributed to the fact that the supernatant was discarded and not included in the analysis (Adane *et al*., 2013). The decreased values of minerals obtained could also be attributed to the higher rate of fermentation (anaerobic) of the aerial potato soaked in water resulting in higher levels of organic acids which in turn form soluble complexes with several minerals which were subsequently discarded with the liquid (Adane *et al*., 2013). The increased calcium content from 9.06±0.05 and 7.73±0.03 at the initial to 11.57±0.01 and 9.03±0.06 at the end of the fermentation (Table 5) in the peeled-blanched and unpeeled-blanched aerial potato (Table 5) suggests a positive role of fermentation on calcium availability in aerial potato which could be attributed to the removal of antinutrients by blanching (Chongtham *et al*., 2021).

Conclusively, fermentation processes increases in the values of nutrients and elemental components of the yam. This will be of advantage to suppress the increasing food insecurity by converting abandon tubers into edible final products.

Table 1: Proximate composition of unpeeled and peeled aerial potato after using different fermentation methods

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	Moisture Content (%)	17.90^{b}±0.05	12.32^{a}±0.23	17.60^{b}±0.05	12.24^{a}±0.23	18.06^{b}±0.32	12.17^{a}±0.32	13.90^{a}±0.24	12.63^{a}±0.59	17.55^{b}±0.21	13.95^{a}±0.29
BSF	Moisture (%)	17.90^{b}±0.05	12.32^{a}±0.23	14.92^{a}±0.01	11.66^{a}±0.20	17.71^{b}±0.46	12.77^{b}±0.14	15.27^{a}±0.02	11.52^{b}±0.09	14.64^{a}±3.09	12.14^{ab}±0.56
STF		17.90±0.05	11.44±1.16	18.99±0.63	15.63±0.31	18.06±0.32	15.02±0.11	13.90±0.24	14.53±0.33	17.55±0.21	14.05±0.16
MCF	Ash (%)	1.09^{a}±0.06	1.03^{a}±0.02	1.09^{a}±0.06	1.13^{a}±0.02	1.05^{a}±0.03	1.13^{ab}±1.21	1.21^{ab}±0.03	1.21^{b}±0.03	1.38^{bc}±0.16	1.26^{bc}±0.08
BSF		1.09^{a}±0.06	1.03^{a}±0.02	1.54^{cd}±0.16	1.30^{c}±0.04	1.38^{bc}±0.12	1.34^{c}±0.12	1.63^{d}±0.07	1.49^{d}±0.06	1.62^{d}±0.11	1.51^{d}±0.16
STF		1.09±0.06	0.99±0.05	1.07±0.04	1.43±0.04	1.05±0.03	1.52±0.05	1.21±0.03	1.56±0.20	1.38±0.16	1.63±0.11
MCF	Fat (%)	2.13^{a}±0.14	2.99^{a}±0.05	2.23^{a}±0.14	2.99^{a}±0.05	2.06^{a}±0.13	3.17^{b}±0.06	3.32^{c}±0.03	3.24^{b}±0.15	2.31^{ab}±0.02	3.59^{c}±0.03
BSF		2.13^{a}±0.14	2.99^{a}±0.05	2.22^{ab}±0.11	3.61^{c}±0.02	2.47^{b}±0.08	3.65^{cd}±0.02	2.74^{c}±0.11	3.67^{cd}±0.14	3.32^{d}±0.33	3.79^{d}±0.07
STF		2.13±0.14	2.06±0.02	2.03±0.32	2.00±0.00	2.06±0.13	1.79±0.04	2.02±0.03	1.75±0.21	2.01±0.02	1.73±0.55
MCF	Fibre (%)	0.77^{a}±0.07	1.12^{b}±0.01	0.79^{a}±0.07	1.12^{b}±0.01	0.81^{a}±0.01	1.01^{b}±0.01	0.81^{a}±0.02	1.01^{b}±0.02	0.77^{a}±0.06	0.95^{a}±0.05
BSF		0.77^{a}±0.07	1.12^{b}±0.01	0.71^{b}±0.09	0.88^{c}±0.05	0.60^{a}±0.06	0.85^{ab}±0.04	0.57^{a}±0.01	0.84^{b}±0.01	0.50^{a}±0.10	0.82^{a}±0.02
STF		0.77±0.07	1.07±0.02	0.87±0.01	1.04±0.11	0.81±0.01	1.02±0.20	0.81±0.02	0.81±0.02	0.77±0.06	0.80±0.01
MCF	Crude Protein (%)	4.12^{a}±0.13	3.66^{a}±0.04	4.36^{a}±0.13	3.71^{a}±0.04	4.84^{b}±0.09	3.80^{a}±0.19	8.40^{d}±0.00	4.12^{b}±0.04	9.11^{c}±0.00	4.19^{b}±0.03
BSF		4.12^{a}±0.13	3.66^{a}±0.04	5.25^{b}±0.10	4.23^{b}±0.12	5.36^{b}±0.03	4.96^{c}±0.00	5.28^{b}±0.09	5.24^{d}±0.16	10.11^{c}±0.85	5.63^{e}±0.02
STF		4.12±0.13	3.54±0.02	4.33±0.11	3.63±0.26	4.84±0.09	3.87±0.19	5.41±0.32	4.11±0.11	8.40±0.00	4.46±0.01
MCF	Carbohydrate (%)	78.43±0.02	80.73±0.11	78.09±0.06	80.75±0.14	77.06±0.02	80.64±0.07	72.60±1.03	81.50±0.01	74.00±0.01	80.79±0.03
BSF		78.11±0.23	82.54±0.33	80.61±1.46	82.55±0.51	77.84±0.21	81.39±0.14	79.79±0.03	82.48±0.02	79.92±0.11	81.74±0.07
STF		79.25±0.02	79.28±0.15	78.71±0.06	79.41±0.17	79.69±0.44	77.84±0.03	76.08±0.01	77.82±0.11	72.74±0.06	77.32±0.02

Table 2: Proximate Composition of peeled and unpeeled blanched after using different fermentation methods

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	Moisture Content (%)	12.51^{b}±0.35	11.44^{a}±1.16	12.59^{b}±0.35	11.37^{a}±1.16	12.95^{a}±0.26	11.31^{a}±0.30	13.64^{b}±0.08	10.71^{a}±0.28	11.46^{c}±0.31	10.44^{a}±0.44
BSF		12.51^{b}±0.35	11.44^{a}±1.16	11.84^{a}±0.24	9.83^{a}±0.51	11.92^{a}±0.37	10.29^{b}±0.12	11.72^{a}±0.18	11.77^{d}±0.32	11.81^{d}±0.15	11.53^{d}±0.53
STF		12.51±0.35	11.44±1.16	11.24±0.24	11.77±0.32	11.36±0.07	13.33±0.16	15.41±0.32	13.51±0.02	15.59±0.22	13.87±0.13
MCF	Ash (%)	0.82^{a}±0.04	0.99^{a}±0.05	0.81^{a}±0.04	0.99^{a}±0.05	0.91^{a}±0.02	1.05^{b}±0.02	1.04^{b}±0.02	1.11^{ab}±0.15	1.08^{b}±0.03	1.22^{bc}±0.10
BSF		0.82^{a}±0.04	0.99^{a}±0.05	1.15^{b}±0.00	1.58^{d}±0.04	1.28^{c}±0.35	1.64^{e}±0.01	1.33^{c}±0.03	1.75^{f}±0.17	1.48^{d}±0.16	1.63^{e}±0.12
STF		0.82±0.04	0.99±0.05	1.17±0.03	1.79±0.15	1.19±0.00	1.63±0.42	1.28±0.14	1.56±0.20	1.49±0.33	1.51±0.07
MCF	Fat (%)	3.35^{b}±0.08	2.06^{a}±0.02	3.36^{b}±0.08	2.06^{a}±0.02	3.43^{ab}±0.14	2.19^{b}±0.07	3.51^{abc}±0.01	2.16^{b}±0.05	3.58^{c}±0.01	2.41^{b}±0.01
BSF		3.35^{b}±0.08	2.06^{a}±0.02	3.68^{c}±0.03	2.45^{c}±0.09	3.89^{d}±0.03	2.61^{c}±0.10	4.01^{d}±0.07	2.83^{d}±0.11	4.49^{e}±0.28	3.01^{e}±0.01
STF		3.35±0.08	2.06±0.02	3.68±0.11	2.36±0.17	2.11±0.40	2.31±0.54	1.01±0.12	2.19±0.36	1.01±0.02	2.04±0.62
MCF	Fibre (%)	0.83^{b}±0.08	1.07^{b}±0.02	0.82^{b}±0.08	1.05^{b}±0.02	0.82^{a}±0.15	1.05^{b}±0.01	0.82^{a}±0.05	1.02^{b}±0.02	0.99^{a}±1.17	0.96^{b}±0.03
BSF		0.83^{b}±0.08	1.07^{b}±0.02	0.61^{a}±0.11	0.93^{b}±0.02	0.67^{ab}±0.00	0.92±^{b}0.02	0.60^{a}±0.06	0.87^{a}±0.01	0.94^{a}±0.03	0.83^{a}±0.01
STF	Fibre (%)	0.83±0.08	1.07±0.02	0.61±0.04	0.87±0.01	0.59±0.21	0.82±0.10	0.55±0.04	0.74±0.31	0.53±0.11	0.75±0.26
MCF	Crude Protein (%)	4.04^{a}±0.00	3.54^{a}±0.02	4.10^{a}±0.03	3.53^{a}±0.05	3.90^{a}±0.03	3.63^{a}±0.05	4.25^{b}±0.00	3.88^{a}±0.13	11.66^{c}±0.00	4.28^{b}±0.00
BSF		4.04^{a}±0.00	3.54^{a}±0.02	4.70^{c}±0.00	4.08^{d}±0.30	5.42^{e}±0.17	4.46^{f}±0.06	5.81^{f}±0.15	5.18^{g}±0.00	10.14^{d}±0.00	5.33^{h}±0.11
STF		4.04±0.00	3.54±0.02	4.50±0.03	5.18±0.00	4.23±0.11	5.22±0.26	4.33±0.26	5.41±0.27	4.80±0.01	5.16±0.03
MCF	Carbohydrate (%)	85.59±0.02	77.13±0.13	85.19±0.01	77.25±0.06	84.45±0.11	79.99±0.02	84.06±0.15	77.88±0.33	75.98±0.02	78.99±0.14
BSF		85.59±0.01	77.13±0.11	81.73±0.05	77.90±0.33	85.56±0.07	75.81±0.01	81.32±1.92	76.79±0.09	73.41±0.02	76.09±0.17
STF		85.59±0.22	77.13±0.14	81.12±0.03	77.31±0.02	81.00±0.11	80.10±0.14	79.86±0.17	78.78±0.23	79.35±0.06	78.96±0.11

Table 3: Proximate Composition of peeled and unpeeled-boiled aerial potato after using different fermentation methods

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	Moisture (%)	6.53^{a}±0.58	15.19^{c}±0.41	6.78^{a}±0.58	15.10^{c}±0.41	7.25^{a}±0.62	12.02^{b}±0.17	7.05^{c}±0.19	13.79^{b}±0.04	7.12^{a}±0.11	11.95^{b}±0.13
BSF		6.53^{a}±0.58	15.19^{c}±0.41	8.51^{b}±0.02	13.20^{b}±0.54	8.82^{b}±0.12	14.40^{c}±0.32	7.07^{a}±0.18	12.61^{a}±0.09	10.18^{c}±0.41	12.96^{a}±0.23
STF		6.53±0.58	15.19±0.41	8.82±0.12	12.61±0.09	10.47±0.11	9.83±0.51	11.58±0.61	10.44±0.11	11.88±0.14	11.61±0.13
MCF	Ash (%)	0.96^{a}±0.06	0.91^{a}±0.04	0.96^{a}±0.06	0.91^{a}±0.04	1.02^{a}±0.01	1.11^{b}±0.05	1.15^{a}±0.17	1.19^{b}±0.07	1.22^{b}±0.18	1.12^{b}±0.03
BSF		0.96^{a}±0.06	0.91^{a}±0.04	1.57^{b}±0.05	1.27^{b}±0.01	1.76^{b}±0.23	1.30^{b}±0.02	1.77^{b}±0.06	1.33^{b}±0.02	1.76^{b}±0.23	1.38^{b}±0.01
STF		0.96±0.06	0.91±0.04	1.76±0.23	1.33±0.02	1.55±0.11	1.58±0.04	1.51±0.15	1.55±0.33	1.43±0.00	1.52±0.04
MCF	Fat (%)	2.05^{a}±0.11	2.16^{a}±0.03	2.15^{a}±0.11	2.16^{a}±0.03	2.56^{b}±0.13	2.20^{a}±0.03	2.67^{bc}±0.08	2.24^{a}±0.01	3.03^{c}±0.11	2.70^{b}±0.11
BSF		2.05^{a}±0.11	2.16^{a}±0.03	2.88^{cd}±0.08	2.62^{b}±0.10	3.19^{e}±0.07	3.11^{c}±0.12	3.43^{f}±0.11	3.22^{c}±0.10	3.73^{g}±0.04	3.41^{c}±0.07
STF		2.05±0.11	2.16±0.03	3.19±0.07	2.70±0.11	2.16±0.37	2.45±0.09	2.17±0.11	2.08±0.31	2.01±0.01	2.00±0.03
MCF	Fibre (%)	0.76^{a}±0.04	1.07^{b}±0.04	0.75^{a}±0.04	1.07^{b}±0.04	0.61^{a}±0.02	0.97^{a}±0.03	0.57^{a}±0.08	0.92^{a}±0.01	0.58^{a}±0.06	0.85^{a}±0.05
BSF		0.76^{a}±0.04	1.07^{b}±0.04	0.56^{ab}±0.06	1.00^{b}±0.02	0.54^{ab}±0.02	0.88^{b}±0.02	0.57^{ab}±0.04	0.55^{a}±0.02	0.47^{a}±0.06	0.52^{a}±0.02
STF		0.76±0.035	1.07±0.04	0.54±0.02	0.85±0.05	0.52±0.20	0.93±0.02	0.50±0.23	0.62±0.11	0.49±0.01	0.53±0.41
MCF	Crude Protein (%)	3.50^{a}±0.04	3.50^{a}±0.00	3.52^{a}±0.04	3.63^{a}±0.00	3.53^{a}±0.00	3.84^{a}±0.03	3.82^{b}±0.11	3.91^{b}±0.00	4.01^{c}±0.00	3.89^{b}±0.06
BSF		3.50^{a}±0.04	3.50^{a}±0.00	4.16^{c}±0.06	4.04^{a}±0.00	4.51^{d}±0.04	4.18^{a}±0.10	4.69^{e}±0.11	4.44^{b}±0.00	5.04^{f}±0.12	4.03^{a}±0.06
STF		3.50±0.04	3.50±0.00	4.51±0.04	3.89±0.06	5.03±0.01	4.08±0.30	5.27±0.04	5.31±0.21	5.76±0.01	5.39±0.40
MCF	Carbohydrate (%)	86.2±1.33	77.17±1.11	85.84±1.34	99.4±0.41	85.07±0.22	78.86±0.81	84.74±0.09	77.95±0.44	83.77±0.52	79.49s±0.06
BSF		86.20±0.13	77.48±0.07	82.32±0.01	77.87±0.06	77.86±0.17	81.17±0.03	83.18±0.43	77.85±0.14	78.82±0.21	77.70±0.05
STF		86.25±1.32	85.94±0.11	82.16±0.02	78.63±0.15	80.27±0.04	81.13±0.32	78.99±0.11	80.00±0.03	78.43±0.16	79.94±0.21

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	**Na (ppm)**	9.38^{d}±0.02	8.91^{d}±0.02	10.99^{h}±0.01	10.48^{h}±0.01	10.58^{f}±0.08	8.95^{e}±0.07	6.60^{a,b}±0.06	6.33^{b}±0.15	5.88^{b}±0.08	5.72^{a}±0.08
BSF		9.67^{e}±0.15	8.91^{d}±0.02	10.99^{h}±0.01	7.93^{d}±0.06	10.67±0.58	9.53^{g}±0.06	6.47^{a}±0.06	6.83^{c}±0.06	11.10^{c}±0.10	9.10^{f}±0.01
STF		8.55±0.11	8.91^{d}±0.02	10.99^{h}±0.01	10.06±0.03	9.73±0.00	10.13±0.00	10.13±0.08	11.31±0.72	10.04±0.11	11.69±0.33
MCF	**K (ppm)**	21.32^{ab} ±5.77	20.04^{ab} ±5.77	25.04^{d}±0.01	24.99^{d}±0.01	25.50^{c}±0.20	24.50^{d}±0.71	17.77^{a}±0.15	18.53^{a}±0.06	19.40^{ab}±0.10	18.43^{a}±0.06
BSF		17.63^{a}±0.01	20.04^{ab} ±5.77	24.99^{d}±0.01	18.97^{a}±0.03	20.53±0.50	25.33^{d}±0.58	21.80±0.10	23.00^{c}±1.00	17.33^{a}±0.15	20.07^{b}±0.06

Table 4: Mineral Composition of unpeeled and peeled aerial Potato after using different fermentation methods

STF		20.00±0.04	20.04±5.77	24.99±0.01	24.96±0.03	21.49±0.03	25.07±0.17	23.43±0.13	25.66±0.31	23.44±0.05	25.73±0.11
MCF	**Ca (ppm)**	7.30^{f}±0.01	7.30^{f}±0.01	8.54^{h}±0.05	8.30^{f}±0.00	6.86^{e}±0.05	8.30^{f}±0.00	5.77^{d}±0.02	5.48^{c}±0.11	8.25^{c}±0.05	5.95^{e}±0.04
BSF		7.75^{g}±0.13	7.30^{f}±0.01	8.54^{h}±0.05	5.46^{c}±0.05	8.45^{h}±0.05	5.59^{d}±0.01	3.82^{a}±0.03	4.95^{b}±0.01	9.03^{b}±0.01	3.59^{a}±0.01
STF		7.03±0.05	7.30±0.01	8.54±0.05	8.57±0.31	8.76±0.02	8.72±0.04	9.11±0.05	8.91±0.11	9.16±0.01	9.03±0.06
MCF	**Mg (ppm)**	10.52^{g}±0.05	11.54^{g}±0.05	10.50^{f}±0.01	9.50^{f}±0.01	8.63^{f}±0.06	6.90^{g}±0.14	6.80^{b}±0.05	6.20^{d}±0.10	5.10^{c}±0.00	5.03^{c}±0.06
BSF		6.21^{e}±0.01	11.54^{g}±0.05	9.50^{f}±0.01	6.50^{e}±0.00	5.68^{d}±0.03	6.40^{e}±0.01	4.20^{a}±0.00	5.20^{c}±0.01	6.08^{c}±0.08	4.52^{a}±0.08
STF		11.51±0.11	11.54±0.05	9.50±0.01	10.22±0.03	13.11±0.30	10.27±0.00	15.09±0.33	11.41±0.03	15.11±0.70	11.76±0.01
MCF	**Fe (ppm)**	0.05^{a}±0.00	0.05^{a}±0.00	0.047^{ab}±0.00	0.047^{ab}±0.00	0.05^{a}±0.00	0.067^{d}±0.00	0.08^{b}±0.00	0.049^{b}±0.00	0.18^{c}±0.01	0.122^{f}±0.00
BSF		0.12^{d}±0.00	0.05^{a}±0.00	0.047^{ab}±0.00	0.089^{e}±0.00	0.05^{a}±0.00	0.049^{b}±0.00	0.05^{a}±0.00	0.045^{a}±0.00	0.18^{b}±0.00	0.055^{c}±0.00
STF		0.05±0.01	0.05±0.00	0.05±0.00	0.07±0.01	0.07±0.01	0.06±0.01	0.17±0.01	0.06±0.00	0.19±0.00	0.06±0.01

Table 5: Mineral Composition of peeled and unpeeled blanched after using different fermentation methods

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	**Na(ppm)**	10.20^{f}±0.20	9.10^{d}±0.01	11.31^{f}±0.20	10.14^{d}±0.01	13.03^{h}±0.06	10.37^{e}±0.15	6.83^{c}±0.15	5.70^{b}±0.00	4.37^{b}±0.12	4.92^{a}±0.08
BSF		10.20^{f}±0.20	9.10^{d}±0.01	9.82^{e}±0.08	12.00^{f}±0.00	10.40^{g}±0.01	8.53^{c}±0.06	5.92^{a}±0.03	8.53^{c}±0.08	11.10^{d}±0.10	9.00^{d}±0.00
STF		10.20±0.20	9.10±0.01	7.82±0.15	9.82±0.08	8.41±0.11	10.40±0.01	10.13±0.08	10.92±0.03	10.04±0.11	11.10±0.10
MCF	**K(ppm)**	29.87^{g}±0.12	22.11^{f}±0.12	27.32^{g}±0.12	23.21^{f}±0.12	21.48^{e}±0.03	24.85^{g}±0.87	16.53^{b}±0.25	21.00^{e}±0.00	15.57^{a}±0.15	17.07^{a}±0.12
BSF		29.87^{g}±0.12	22.11^{f}±0.12	19.52^{c}±0.07	17.65^{b}±0.00	23.07^{f}±0.06	19.80^{c}±0.05	20.33^{c}±0.58	20.92^{e}±0.08	16.82^{b}±0.08	20.00^{d}±0.00
STF		29.87±0.12	22.11±0.12	24.55±0.20	19.52±0.07	24.63±0.15	23.07±0.06	23.43±0.15	23.33±0.58	23.44±0.11	24.06±0.08
MCF	**Ca(ppm)**	9.06^{h}±0.05	7.73^{h}±0.03	7.16^{h}±0.05	7.73^{h}±0.03	6.36^{f}±0.05	5.9^{d}5±0.05	7.23^{g}±0.01	6.24^{f}±0.02	11.57^{c}±0.01	4.63^{c}±0.00
BSF		9.06^{h}±0.05	7.73^{h}±0.03	4.94^{d}±0.05	6.17^{e}±0.01	6.19^{e}±0.01	7.27^{g}±0.00	3.86^{b}±0.01	3.57^{b}±0.00	6.95^{a}±0.01	3.51^{a}±0.11
STF		9.06±0.05	7.73±0.03	7.13±0.00	8.57±0.31	7.42±0.01	8.72±0.04	7.06±0.13	8.91±0.11	7.01±0.00	9.03±0.06
MCF	**Mg(ppm)**	8.61^{h}±0.01	10.20^{h}±0.00	7.42^{h}±0.01	9.16^{h}±0.00	5.82^{e}±0.03	5.60^{d}±0.00	6.22^{f}±0.04	5.40^{c}±0.00	4.62^{b}±0.08	5.03^{b}±0.06
BSF		8.61^{h}±0.01	10.20^{h}±0.00	8.21^{g}±0.21	5.92^{e}±0.08	4.80^{c}±0.01	6.21^{f}±0.02	4.30^{a}±0.05	3.92^{a}±0.08	5.43^{d}±0.06	6.40^{g}±0.02
STF		8.61±0.01	10.20±0.00	8.43±0.05	10.26±0.14	8.01±0.02	10.19±0.31	8.00±0.10	10.03±0.03	7.31±0.20	10.01±0.11
MCF	**Fe(ppm)**	0.055^{b}±0.00	0.102±0.00	0.055^{b}±0.00	0.102±0.00	0.072^{c}±0.00	0.039±0.00	0.072^{c}±0.00	0.099±0.00	**0.183^{e}±0.01**	0.113±0.01
BSF		0.055^{b}±0.00	0.102±0.00	0.047^{a}±0.00	0.064±0.00	0.081^{d}±0.00	0.072±0.00	0.055^{b}±0.01	0.066±0.00	0.18^{d}±0.00	0.056±0.01
STF		0.06±0.00	0.102±0.00	0.07±0.01	0.10±0.01	0.03±0.00	0.09±0.01	0.02±0.01	0.04±0.00	0.02±0.00	0.03±0.00

Table 6: Mineral Composition of peeled and unpeeled-boiled aerial potato after using different fermentation methods

Sample and fermentation time		0 h Peeled	0 h Unpeeled	24 h Peeled	24 h Unpeeled	72 h Peeled	72 h Unpeeled	120 h Peeled	120 h Unpeeled	168 h Peeled	168 h Unpeeled
MCF	**Na(ppm)**	9.43^{e}±0.06	10.73h±0.02	9.53^{e}±0.06	9.03±0.02	9.23^{g}±0.06	8.83g±0.06	8.33^{d}±0.06	7.23c±0.06	6.23^{a}±0.06	5.03a±0.06
BSF		9.43^{e}±0.06	10.73h±0.02	9.90^{f}±0.10	8.71e±0.01	12.10^{h}±0.10	9.60f±0.20	8.00^{c}±0.01	5.60b±0.00	7.53^{b}±0.06	8.43d±0.06
STF		10.99±0.01	9.67±0.15	8.95±0.07	10.67±0.58	6.33±0.15	6.47±0.06	6.13±0.08	6.39±0.04	6.04±0.11	6.07±0.33
MCF	**K(ppm)**	21.63^{g}±0.06	25.70a±0.10	21.22^{g}±0.06	25.70a±0.10	20.71^{e}±0.05	25.60±0.53	18.27^{c}±0.06	11.72a±8.63	17.51^{a}±0.02	16.83ab±0.15
BSF		21.63^{g}±0.06	25.70a±0.10	21.13^{f}±0.02	18.53b±0.02	18.60^{d}±0.26	17.90b±0.01	17.93^{b}±0.06	18.70b±0.01	18.07^{b}±0.06	18.43b±0.06
STF		24.99±0.01	17.63±0.01	24.50±0.71	20.53±0.50	18.53±0.06	21.80±0.10	19.41±0.01	21.42±0.07	19.33±0.12	21.19±0.01
MCF	**Ca(ppm)**	7.06^{g}±0.05	8.38h±0.02	7.67^{g}±0.05	6.32h±0.02	5.57^{e}±0.01	5.85e±0.01	4.93^{d}±0.01	6.32g±0.03	4.45^{b}±0.00	4.41c±0.01
BSF		7.06^{g}±0.05	8.38h±0.02	6.69^{f}±0.01	5.73d±0.01	9.04±0.00	5.94f±0.01	4.73^{c}±0.01	4.36b±0.01	3.64^{a}±0.01	4.21a±0.01
STF		8.54±0.05	7.75±0.13	8.30±0.00	8.45±0.05	5.48±0.11	3.82±0.03	7.06±0.13	3.55±0.17	7.01±0.33	3.05±0.22
MCF	**Mg(ppm)**	10.43^{f}±0.06	6.82f±0.03	10.79^{f}±0.06	6.82f±0.03	5.83^{c}±0.06	11.00g±0.00	7.00^{d}±0.01	4.62a±0.02	5.23^{b}±0.06	6.43e±0.06
BSF		10.43^{f}±0.06	6.82f±0.03	8.43^{e}±0.06	6.30d±0.01	7.00^{d}±0.00	4.90b±0.00	3.83^{a}±0.06	4.57a±0.06	5.23^{b}±0.06	6.20c±0.01
STF		9.50±0.01	6.21±0.01	16.90±0.14	5.68±0.03	16.44±0.00	4.20±0.00	15.20±0.10	4.06±0.33	15.06±0.10	3.96±0.60
MCF	**Fe(ppm)**	0.403^{a}±0.51	0.10d±0.02	0.403^{a}±0.51	0.10d±0.02	0.239^{a}±0.31	0.06b±0.00	0.073^{a}±0.00	0.10d±0.00	0.107^{a}±0.01	0.13e±0.00
BSF		0.403^{a}±0.51	0.10d±0.02	0.11^{a}±0.00	0.08c±0.00	0.05^{a}±0.00	0.06b±0.00	0.043^{a}±0.00	0.070b±0.00	0.098^{a}±0.00	0.032a±0.02
STF		0.047±0.00	0.12±0.00	0.067±0.00	0.05±0.00	0.05±0.00	0.05±0.00	0.02±0.01	0.04±0.00	0.02±0.00	0.03±0.00

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