

Original Research Article

Sweet potato varietal evaluation trial for food nutritional values

Abstract:

Aim: To explore the nutrient, mineral, beta carotene and total carotenoid capabilities of five varieties of sweet potato.

Study design: Vines of the various varieties were cultivated in parallel lines on the same bed

Results: All five varieties of sweet potato are nutritious. Protein content ranges from 3.82% in Agric white variety to 0.11% in Agric orange flesh. Fat, from 4.84% in orange flesh variety to 1.74% in red skin. Crude fibre content was between 1.77% in Agric orange flesh and 0.10% in T.U. purple. Total carbohydrate, from 23.2% in Agric orange flesh variety to 15.8% in Agric white one. Moisture is high in all the varieties, ranging from 75.78% in Agric white variety to 71.04% in Orange flesh one. The orange flesh variety has the highest ash content of 1.56%. All the varieties contain high concentrations of Mg but low concentrations of Na and K. The highest concentration of Ca (8250.70 ± 0.062 mg/kg) was recorded by T.U. purple. The concentrations of Fe in the sweet potato varieties decreases in the order: T.U. purple > Red skin > Orange flesh > Agric orange flesh > Agric white. The highest Zn concentration of 123.12 ± 0.004 mg/kg in orange flesh variety and lowest (33.10 ± 0.002 mg/kg) in Agric white was observed. The concentration of beta carotene (mg/kg) in five sweet potato varieties increases in the order Agric orange flesh << Agric white < Red skin < Orange flesh < T.U. purple.

Conclusion: The five varieties of sweet potato are rich in proteins, carbohydrates, fats and oils. They are observed with variability in macro- and micronutrients, beta carotene and total carotenoids. T.U. purple variety was identified with richest source of Ca and beta carotene. The varieties of sweet potato may thus be of considerable importance in ameliorating

Comment [SN1]: Methodology was missing in abstract's subsection

Comment [SN2]: Please include design that is appropriate for screening varieties for nutrient trials, and Whether it is line sowing, if replicated, randomized the varieties while planting within each line and between lines, how many number of lines were used for five varieties. Further, genotypes will be effected by the growing location and soil., what are the measures taken to maintain soil homogeneity? informaiton on organic manure etc, should be incorporated as necessary in methods section.

Comment [SN3]: Place and duration of the study is missing in the abstract section

Comment [SN4]: Data and results of oils is missing

26 nutrient, mineral as well as beta carotene malnutrition in resource poor areas of developing
27 countries.

28 **Key words:** sweet potato varieties, nutrient, minerals, beta carotene.

29 1.0 Introduction

30 1.1 Background:

31 Varieties of *Ipomea batatas*, commonly called sweet potatoes, recognizable by the different
32 skin colors of white, cream, yellow, orange, pink, red or purple and / or flesh colors of white
33 or cream, yellow, orange or purple ([1]; [2]). The vegetable tuber crop, sweet potato ranks
34 among the top five most important staple food crops in the world, including rice, wheat,
35 maize and cassava. Sweet potatoes are rich not only in the major minerals such as potassium
36 (K), sodium (Na), calcium (Ca), magnesium (Mg), Sulphur (S) and Phosphorus (P) which are
37 associated with carbohydrates, proteins and fats but also in vitamins A and C, and the trace
38 elements; zinc (Zn), manganese (Mn), iron (Fe), Copper (Cu) and Iodine (I) ([3]; [4]; [1]; [5];
39 [6]; [7]; [8]; [2]). Sweet potato was also known to contain many valuable phytochemicals
40 like phenol-related chlorogenic acid, anthocyanins; antioxidants; anti-cancer chemicals and
41 carotenoids ([9]; [10]).

42 According to Mitra [11], sweet potatoes can help to heal from liver injury. They are one
43 among the cheapest biofortified food resources, easily accessed by the average person that
44 help ameliorate nutrient deficient conditions in humans. Their versatility and relative ease of
45 cultivation, impregnation with vitamin A precursors, vitamin C and minerals coupled with
46 rich sources of proteins and carbohydrates enabled their cultivation in more than a hundred
47 countries in the world, though appreciable tonnage is produced in China and other developing
48 countries ([1]; [5]; [6]; [7]; [8]; [11]; [2]; [9]; [10]).

49 Recent world statistical data [12] reported China as the lead producer of sweet potatoes
50 accounting to 70,526,000 metric tons per year, which constitute far more than half (68.6%) of

Comment [SN5]: Please remove the subsection for the background information, and there were no other information attached to introduction beyond the statistics of cultivating sweet potato. Please include background information on nutritional trait -varietal evaluations conducted in sweet potato to date

51 the total global production. Tanzania and Nigeria follow in that order with 3,470,304 metric
52 tons and 3,450,000 metric tons respectively, each sharing a proportion of 3.3% of world's
53 production. Indonesia and Uganda are fourth and fifth in the world in terms of sweet potato
54 cultivation, contributing a combined 4% of total production.
55 Ghana produced 143,111 tons of sweet potatoes in 2016 from an area covering 76,594 ha of
56 land. This constituted a share of 0.1% of total potato production in the world during 2016 and
57 ranked Ghana at number 37 in the world with respect to sweet potato production [13]. The
58 data shows that the production of the crop in Ghana has increased in a decade, given that
59 earlier records, posted a production of 90,000 tons from an area of 65,000 ha ([12] [14]).
60 Bidzakin and co-workers [14] during the Ministry of Food and Agriculture (MFA) field
61 survey in 2012 reported that in Ghana, upper east is the region with the highest sweet potato
62 cultivation, producing 46,000 metric tons, with 34.9% total production in Ghana, from an
63 area of land covering 5,550 ha, which is 57.7% of total land used for the crop production in
64 Ghana. Northern and upper west regions follow in that order with respect to both the area of
65 land devoted to potato production and the tonnage produced per annum.
66 However, the data from the upper east regional office of the MFA showed a steady decline in
67 the production of sweet potatoes from 2008 to 2017, after a steep rise in production from
68 2007 to 2008 (Figure 1).

Comment [SN6]: The last two sentences in paragraph one were missing references, if it sthe same reference that was cited for the statistical data, please ignore the comment.

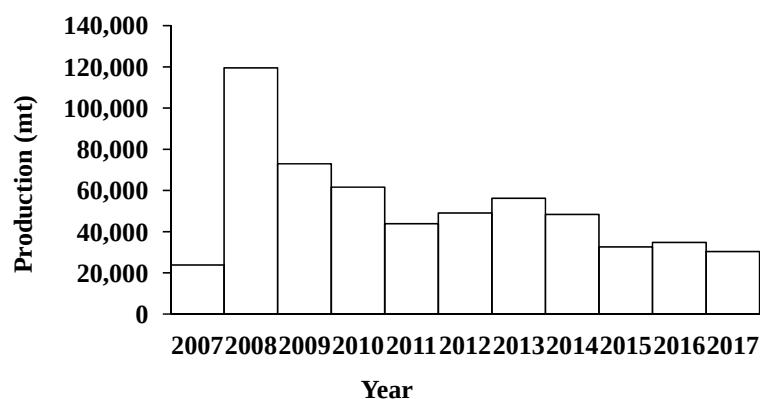


Figure 1: Annual production of sweet potatoes in metric tons (mt) from 2007 to 2017.

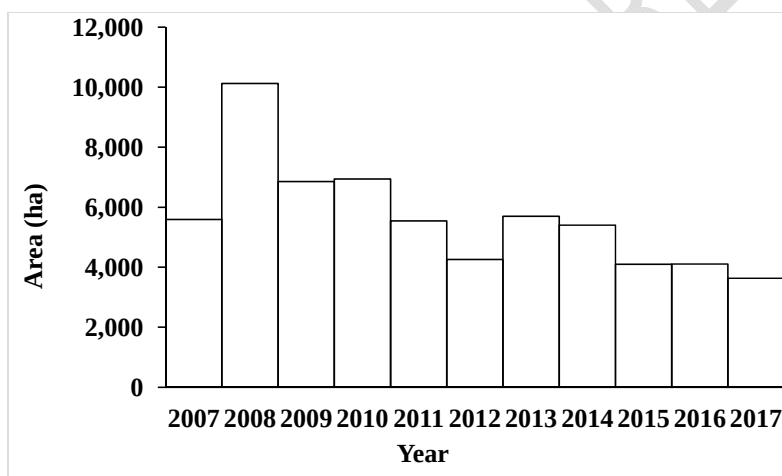


Figure 2: Area of land (ha) used in the production of sweet potatoes from 2007 to 2017

The data also show that farmers progressively devoted less land for cultivation of the crop (Figure 2). Farmers in this region were reported lack of planting materials (sweet potato seeds/slips), farm inputs, implements and a ready market to purchase their farm produce to have increased productivity from sweet potato cultivation [14]. This may account the loss of interest in cultivating this crop. Though provision of above inputs may improve the

80 production, the nutrients available in the crop may encourage the consumption of the crop
81 produce, a major determining factor to increase the demand for the crop thereby enhancing
82 market and increasing sweet potato production. The nutrient contents of different varieties of
83 the crop were investigated and reported by various scientists. However, it has been an
84 established fact that the type and concentration of macro- or micronutrients as well as other
85 phytochemicals in any given crop is dependent on the respective availability and
86 concentration of the same in the soil on which the crop is grown ([1]; [5]; [15]; [6]; [7]; [2]).
87 Thus the same crop grown in different geographic regions may be biofortified with different
88 concentrations of the same or different elements all together. Therefore it is necessary for
89 crops grown in different geographic locations to be analysed to ascertain their nutrient worth
90 and biofortification with vitamins or minerals which have health benefits. However, the
91 nutrient content of different varieties of a crop can be compared when they are cultivated at
92 the same location with similar soil conditions. The study seeks to find out the proportions of
93 food substances such as crude protein, carbohydrates and fat; total carotenoids and beta
94 carotene as well as some major and minor minerals that reside in the sweet potatoes grown in
95 parts of the upper east region.

96

97 2.0 Methodology

98 2.1 The study site:

99 The Bolgatanga Municipality (10.7875° N, 0.8580° W) is a developing city (Figures 3 and 4)
100 with a total population of 131,550, more than half (52.3%) of which is females with males
101 constituting 47.7% of the population. About half (50.2%) of the population in the
102 Municipality is rural [16].

Comment [SN7]: Author mentioned study design, but did not clearly stated about the homogeneity of soil samples of the soil bed chosen., to eliminate the soil heterogeneity factor in screening variety's potential contribution of nutrients from same bed



Figure 3: Map of Bolgatanga Municipality.

Figure 4: Map of Ghana showing location of Bolgatanga (B) in UER

The Municipality experiences a longer dry season from October to May and a shorter rainy season which may begin in June or July to end in October. The mean annual rainfall ranges between 600mm and 1400mm. The mean temperature is about 21°C which can rise to 45°C in March or April. The effect of these conditions is a natural vegetation comprising mainly of guinea savannah woodland. Plant species are deciduous trees widely spaced and a ground flora, which gets spent due to the scorching by the sun and animal grazing during the long dry season. Eighty percent (80%) of the economically active population engage mainly in subsistent agriculture cultivating *Zea mays* (maize), *Pennisetum glaucum* (millet), *sorghum bicolor* (guinea-corn), *sorghum vulgare* (sorghum), *Oryza sativa* (rice), *Arachis hypogaea* (groundnuts), *Phaseolus vulgaris* (beans) and *Ipomea batatas* (sweet potatoes) during the rainy season. However, in the dry season, *Lycopersicon esculentum* (tomatoes), *Allium cepa* (onions) and *Oryza sativa* (rice) are grown in irrigated areas.

2.2 Acquisition of sweet potato vines

Vines of the five different varieties of sweet potatoes were acquired from Dukumah Garden (Agric orange flesh and Agric white) in Bolgatanga and other farms in Sumbungu (Orange flesh, Red skin, T.U. purple).

Comment [SN8]: Please place the Ghana Map below the city and increase the font size to match with rest of the article.

Comment [SN9]: Please revise the para by removing scientific names and common names are sufficient to list for the purpose of the context.

Comment [SN10]: Vines or Vine cuttings or slips?

2.3 Cultivation of sweet potato varieties

The germinated vines at ---- week stage with --number of leaves were transplanted in parallel line on the same bed in Dukumah Garden, so that their performance with respect to nutrient content can be compared. The organic manure containing ---- was applied evenly to all lines (Source). No synthetic fertilizer was applied.

Comment [SN11]: Please fill the blanks with details of transplanting age of vines of sweet potato varieties.

Comment [SN12]: Please describe the composition of the organic manure and the source of acquisition.

2.4 Harvesting and nutrient analysis of sweet potato varieties:

The sweet potatoes were harvested after four months on the same day. Samples of the various varieties were taken, parcelled, appropriately labelled and hand delivered to the Food Chemistry laboratory of Kwame Nkrumah University of Science and Technology for the following analysis:

Comment [SN13]: Please specify the details of the harvest, is it after four months of maturity of tuber formation, or four months after transplanting?

Comment [SN14]: Please provide the details of the analysis protocol adopted in the same section and there is no requirement for another sub head 2.5.

- i. Proximate analysis in percentages (%),
- ii. Total carotenoids and beta carotene in milligrams per gram (mg/g) and
- iii. Concentration of the minerals Magnesium (Mg), Sodium (Na), Potassium (K), Calcium (Ca) Iron (Fe) and Zinc (Zn) in milligrams per kilogram (mg/kg)

2.5 Official Methods of Analysis:

- i. Proximate and carotene ([17] [18])
- ii. Minerals: Atomic absorption spectrophotometer, AAS Model Nov AA 400p

Each treatment (variety) samples were analysed in duplicates and the average values recorded.

The five sweet potatoes varieties were coded as follows: Agric Orange flesh (AO), Red Skin (RS), Agric White (AW), Orange flesh (OF) and T.U. Purple (TP).

Comment [SN15]: Please describe the AOAC methods, variables and samples with quantities taken for measurements using instruments as specified in the standard protocol. Please include a section for statistical analysis that was followed for analysis of results., might be 2.5;

3.0 Results

148 **3.1 Colours of the different varieties:**

149 The colours of the five different varieties of sweet potatoes (shown with their vines in plates
150 1 to 5), grown in the Bolgatanga Municipality which have been analysed are described as
151 follows: Three varieties had coloured flesh. They include Agric orange flesh and Orange
152 flesh which are much alike, having both skin and flesh in orange colour and T.U. purple
153 whose skin and flesh are purple. The remaining two varieties are Agric white that has white
154 skin and flesh while the Red skin has a red skin but a white flesh.



155 **Plate 1: Agric orange flesh**

156 **Plate 2: Agric white**

Plate 3: Red skin



158 **Plate 4: Orange flesh**

159 **Plate 5: T.U. purple**

160 **Comment [SN16]:** Please align the images/picture labels with respective images

161

162 3.2 Proximate analysis:

163 The proximate composition of the various varieties is shown in Table 1. The results reveal
 164 that the Agric white (AW) variety has the highest moisture of 75.79%, protein content of
 165 3.82% and the lowest total carbohydrate content of 15.80%, being 15.69% nitrogen free
 166 extract (NFE) and 0.11% crude fibre. The Agric orange flesh (AO) variety, on the other hand,
 167 has the lowest protein content of 0.11% but the highest total carbohydrate percentage of
 168 23.20%, being 1.77% crude fibre and 21.43% NFE. The orange flesh variety has the second
 169 highest protein proportion of 1.53% after AW, while the latter also has the second highest
 170 composition of fat (3.37%), after the former (OF), which has the highest lipid composition of
 171 4.84%.

172 **Table 1: Proximate analysis of five varieties of sweet potatoes**

SPV	% Moisture	%Ash	%Crude fibre	%Protein	%Fat	%NFE	%TC
AO	73.38	0.10	1.77	0.11	3.22	21.43	23.2
RS	73.84	0.83	0.99	0.62	1.74	21.98	22.96
AW	75.78	1.23	0.11	3.82	3.37	15.69	15.80
OF	71.04	1.56	0.64	1.53	4.84	20.39	21.03
TP	74.42	0.76	0.10	0.68	2.76	21.29	21.38

173 SPV: Sweet potato variety, AO: Agric orange flesh, RS: Red skin, AW: Agric white, OF: Orange flesh, TP: T.U. purple

174 NFE: nitrogen free extract, TC: total carbohydrates.

175

176 **Table 2: Mineral composition of the five sweet potato varieties.**

	Concentration in mg/kg					
SPV	Mg	Na	K	Ca	Fe	Zn

Comment [SN17]: Table 1: If these are mean comparisons, please include the SD , CV values, to know the critical differences with statistical significance

AO	13322.4 4±0.098	2810.54 ±0.047	4444.77 ±0.030	6282.49± 0.200	38.47± 0.006	36.49±0. 002
RS	9651.17 ±0.017	1887.24 ±0.094	3711.48 ±0.191	3944.48± 0.126	85.91± 0.007	105.16± 0.001
AW	12253.9 9±0.10	1786.77 ±0.074	4882.07 ±0.078	4704.79± 0.079	7.71±0. 003	33.10±0. 002
OF	13713.4 4±0.069	1669.88 ±0.051	5265.03 ±0.023	4707.05± 0.023	47.62± 0.008	123.12± 0.004
TP	10788.3 1±0.066	2073.07 ±0.098	4382.20 ±0.082	18250.70 ±0.062	101.33 ±0.007	66.35±0. 009

Comment [SN18]: Table 2: Please know that it is required to present numerical data upto two decimals only.

SPV: Sweet potato variety, AO: Agric orange flesh, RS: Red skin, AW: Agric white, OF: Orange flesh, TP: T.U. purple

3.3 Mineral composition of the five sweet potato varieties

Concentrations of four major minerals: magnesium (Mg), sodium (Na), potassium (K), calcium (Ca) and two minor ones: iron (Fe) and zinc (Zn) were presented in Table 2. All five varieties of sweet potatoes contain these elements in varying concentrations in milligrams per kilogram (mg/kg). All the five sweet potato varieties contain Mg in appreciably high concentrations and T.U. purple recorded the highest concentration of Ca (18250.70±0.062 mg/kg) than the other varieties. The rest of the varieties recorded moderate concentrations of Ca. Again, all the varieties contained low concentrations of Na and K. The varieties TP, RS and OR contained comparatively higher concentrations of the two minor minerals (Fe and Zn) than varieties AO and AW.

The variety OF has the highest concentration of Mg (13713.44±0.069 mg/Kg), K (5265.03±0.023mg/kg) and Zn (123.12±0.004 mg/Kg) but has the lowest concentration of Na (1669.88±0.051 mg/kg). The variety RS has the second highest concentration of the minor

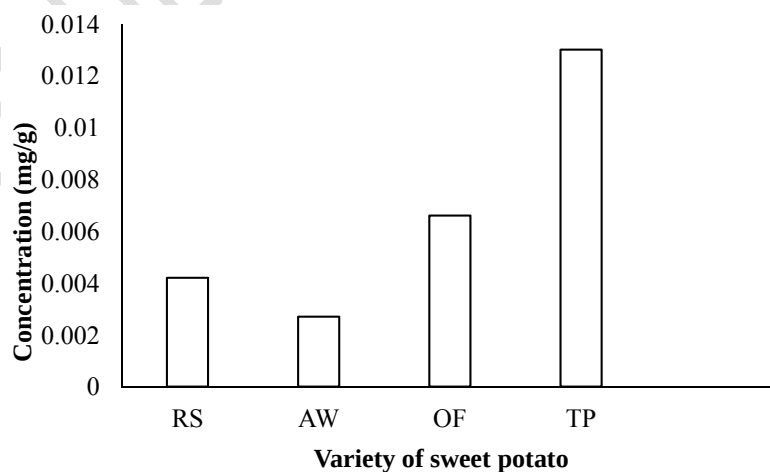
minerals, Fe (85.91 ± 0.007 mg/Kg) and Zn (105.18 ± 0.001 mg/Kg) while the variety AO has a concentration of 13322.44 ± 0.098 mg/Kg of Mg and 6282.49 ± 0.200 mg/Kg of Ca. On the other hand, the AW variety has the second highest concentration of K (4882.07 ± 0.078 mg/Kg). The variety TP has the highest concentration of Fe (101.33 ± 0.007 mg/Kg) and Ca (18250.70 ± 0.062 mg/Kg). The AW variety was observed with the lowest concentration in mg/kg of the trace elements: Fe (7.71 ± 0.003) and Zn (33.10 ± 0.00) while the lowest concentrations in mg/kg of Mg (9651.17 ± 0.017), K (3711.48 ± 0.191) and Ca (3944.48 ± 0.126) were recorded in the variety RS.

200

201 3.4 Total carotenoids and Beta carotene

Figures 5 and 6 illustrates the beta carotene and total carotenoids concentration in milligrams per gram (mg/g), respectively found in the five sweet potato varieties. The orange flesh (OF) variety recorded the highest concentration of total carotenoids (1.6454) while T.U. purple (TP) contained the highest concentration of beta carotene (0.0130). The lowest concentrations of total carotenoids and beta carotene were recorded in the red skin (RS) (0.1097) and Agric orange flesh (AO) (0.0009) respectively.

208



209

Comment [SN19]: Please avoid the repetitive use of expanded version of variety names when they are coded.

Figure 5: Beta carotene concentration (mg/g) in varieties of sweet potatoes

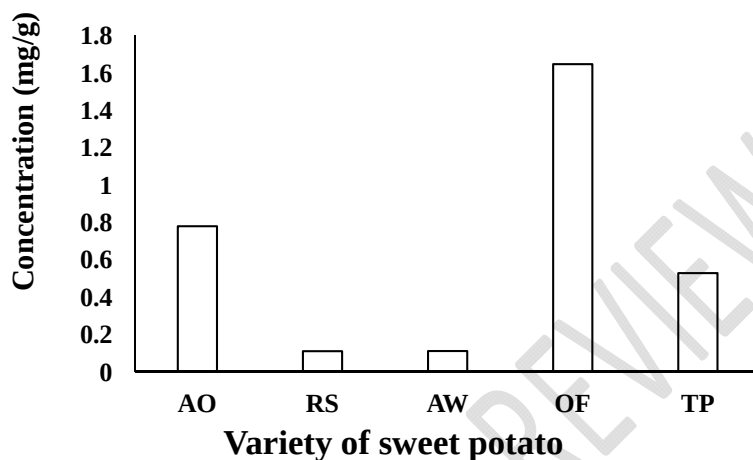


Figure 6: Total carotenoids concentration (mg/g) in varieties of sweet potatoes

4.0 Discussion

The research aimed to grow the varieties of sweet potato together on the same farm and under the same edaphic conditions so that their respective nutrient, mineral, beta carotene and total carotenoid capabilities could be explored. The findings show that all five varieties of sweet potato are nutritious, with protein content ranging from the highest of 3.82% in the Agric white variety to the lowest of 0.11% in the Agric orange flesh. This finding is different from that reported in Benin [19], which suggested that white fleshed sweet potato varieties contain less protein than the coloured flesh ones. The range of protein content observed from current study was found similar to the range of 3.3% to 1.2% reported from five varieties in Sri Lanka [20]. It is however, much higher than the range of 0.91% to 0.05% reported by Rwanda [6]. The observed protein range is lower than the range of protein content (4.16% to

3.28) recorded in Nigeria [21], China (6.53% to 4.86%) [22] and Benin (4.09 to 1.97%)[19].

The Agric white variety (AW), with its high protein content, may thus be of importance in the amelioration of protein malnutrition in resource poor areas of developing countries.

All five varieties of sweet potato contain considerable percentage of fat, ranging from 4.84% in the orange flesh (OF) variety to 1.74% in the red skin (RS) one. The content of fat in the five varieties increases in the order of RS<TP<AO<AW<OF. A much higher range of fat content ($8.88\pm0.30\%$ to $0.54\pm0.13\%$) was recorded in Benin [19]. Given the importance of lipids as a component of lipopolysaccharide in the plasma membranes of cells, the considerable fortification of some of the sweet potato varieties with fat may help to improve the health-status of the rural poor. On the other hand, the moderate fat content in the other varieties, especially RS and TP, makes them useful food for people who are concerned about consuming high fatty foods.

Crude fibre content was found to range between 1.77% in the Agric orange flesh (OF) and 0.10% in T.U. purple (TP) in this study, much higher than the range of 0.14% to 0.11% reported earlier by Rwanda [6]; but much lower than the range (2.35% -1.85%) reported in China [8]; the range (13.60% to 2.10%) observed in Sri Lanka [20]; the range of 5.40 to 3.30% recorded in Martinique [23] and the range of 3.00 to 1.81% [19] in Benin. Foods rich in crude fibre may reduce the likelihood of one experiencing various sicknesses such as those related to the digestive system; sugar related health issues and heart problems ([6]; [24]).

Total carbohydrate content in the varieties of sweet potato studied was ranging from 23.2% in the Agric orange flesh variety to 15.8% in Agric white one, which is lower than the range (38.92 ± 0.04 to $14.46\pm0.07\%$) reported in Benin [19]. Thus, sweet potato cultivating rural folks of developing countries have access to cheap but good source of calories from this crop.

A moisture content ranging from 75.78% in the Agric white variety to 71.04% in the Orange flesh one, was observed higher than the finding of a range between 64.34% and 62.58% in

253 Rwanda [6] and 70.0% to 61.00% in Nigeria [21]. This shows that the five sweet potato
 254 varieties have very high moisture content. This may have impact on the taste when freshly
 255 harvested sweet potatoes are cooked immediately. The average high moisture content in the
 256 five varieties may account for the general low ash content, given that the orange flesh variety
 257 which recorded the lowest moisture of 71.04% has the highest ash content of 1.56%.
 258 According to Ingabire and Vasanthakalam [6], high moisture in sweet potatoes is the cause
 259 of their low ash content.
 260 The study revealed varying concentrations of Mg, Na, K, Ca, Fe and Zn in sweet potato
 261 varieties tested. The highest concentration of Mg (13713.44 ± 0.069 mg/kg) was found in the
 262 orange flesh (OF) variety whereas its lowest concentration (9651.17 ± 0.017 mg/kg) was
 263 recorded in the red skin variety. Mg was observed at higher concentrations in all five varieties
 264 of sweet potato in this study. Thus any of the five varieties is a good source of this major
 265 mineral. A recent study in Bennin [25] reported a lower concentration range of Mg (2540.00
 266 to 2130.00 mg/kg) than that of the current study.
 267 Of the four major minerals studied, the Na concentration is the lowest recorded in all five
 268 sweet potato varieties with an average of 2044.29 mg/kg. This concentration of Na is lower
 269 than the range of 3400.00 to 2900.00 mg/kg reported in Bennin [25].
 270 The concentration of K is low in all five sweet potato varieties, averaging 4537.11 mg/kg,
 271 though this is more than twice the average concentration of Na. Thus, these sweet potato
 272 varieties may not be rich sources of K and Na, more so, the latter. This low range of K
 273 concentration is much lower than that reported in Western Kenya (16838.00-1040.00 mg/kg)
 274 [2] and in Bennin (32867.00 to 30867.00 mg/kg) [25].
 275 The highest concentration (mg/kg) of Ca (18250.70 ± 0.062 and 101.33 ± 0.007) were
 276 found in the T.U. Purple (TP) variety and the lowest concentration of Ca (3944.48 ± 0.126)
 277 and Fe (7.72 ± 0.003) were recorded in the red skin (RS) and Agric white (AW) varieties

278 respectively. The highest concentration (mg/kg) of Ca (18250.70 ± 0.062) was observed in the
279 T.U. purple variety (TP) and it is the highest concentration of all the minerals found. T.U.
280 purple (TP) therefore, is the richest source of Ca, out of the five varieties. On the other hand,
281 the concentrations of Fe in the sweet potato varieties decreases in the order:

282 TP>RS>OF>AO>AW. The Ca concentrations recorded in this work is much higher than that
283 recorded by Senanayake et al. in Sri Lanka for Ca (590.00 to 210.00 mg/Kg) [20]. However,
284 the previously reported Fe concentration (630.00 to 420.00 mg/Kg), was much higher than
285 that was observed from the current research work. In the similar way, the Ca concentration
286 recorded in the current study is much higher than the concentration range of 2735.00 to
287 1850.00 mg/kg in varieties of sweet potato reported in Western Kenya [2] while their Fe
288 concentration of (140.00-103.00 mg/kg) is higher than that was recorded by the varieties used
289 in this study. Again, the current finding shows a higher concentration ranges of these
290 minerals than that found in Bennin [25] between 2997.00 and 2304.00 mg/kg for Ca and
291 73.00 to 53.00 mg/kg for Fe.

292 The trace element, Zn recorded highest in concentration of 123.12 ± 0.004 mg/kg in the orange
293 flesh (OF) variety and lowest (33.10 ± 0.002 mg/kg) in the Agric white (AW) variety.
294 Similarly, the concentrations of Zn in the sweet potato varieties decreases in the order:
295 OF>RS>TP>AO>AW. This concentration range of Zn is much higher than the range of
296 27.00 to 23.00 mg/kg recorded in Benin recently [25].

297 The concentration of beta carotene (mg/kg) in the five sweet potato varieties increases in the
298 order AO<<AW<RS<OF<TP, where the highest concentration of 0.0130 mg/kg was
299 recorded in the T.U. purple variety while the lowest concentration of 0.0009 mg/kg was
300 recorded in the Agric orange flesh variety. An earlier study [21] reported beta carotene
301 content ranging from 0.0071 to 0.0060 mg/kg in Nigeria, which is within the current values
302 recorded. The white coloured varieties (AW) contained 0.0027 mg/kg and the red skinned

Comment [SN20]: Please avoid repetition of results in the discussion or merge both results and discussion sections to avoid repetitive use of the information and data presented.

Comment [SN21]: Please include discussion for any observed variation between the varieties used in the present research study compared to those reported in other areas, either phenotypically (textural, structural, morphological) or genotypically (genetic background /parents/genetic source of the variety tested).

303 and white fleshed variety (RS) recorded 0.0042 mg/kg of beta carotene, contrasting
304 differently from earlier findings of no beta carotene at all in white sweet potato varieties ([6];
305 [2]). In this study, T.U. purple (TP) is the variety that may be recommended as a beta
306 carotene supplementary food, followed by the orange flesh (OF) variety.
307 However, in keeping of view of the earlier reports ([6]; [2]), the two white fleshed varieties
308 (AW and RS) recorded the lowest concentration of total carotenoids of 0.11 mg/kg each
309 while the Orange flesh (OF) variety has the highest content of 1.6454 mg/kg.
310 Given that all the varieties were cultivated on the same beds with the same soil type, soil
311 nutrient content and moisture, their levels of nutrient fortification can be attributed solely to
312 the variety of sweet potato and not variation in the soil type ([1]; [5]; [15]; [6]; [7]; [2]).

Comment [SN22]: Please include the soil type, nutrient status of the soils during experimental cultivation period along with the organic manures applied

314 4.1 Conclusion

315 The five varieties of sweet potato are not only rich in varying degrees of proteins,
316 carbohydrates, and fats contents and oils, but are also impregnated with both macro- and
317 micronutrients, beta carotene and total carotenoids. The highest sources of protein and fat are
318 Agric white and orange flesh varieties respectively whereas the Agric orange flesh variety
319 contains the greatest proportions of both total carbohydrate and crude fibre. All varieties
320 contain high amounts of Mg. The T.U. purple variety is the richest source of Ca and beta
321 carotene, compared to the rest. All the varieties of sweet potato contain moderate to low
322 concentrations of K and Na respectively. The varieties of sweet potato may thus be of
323 considerable importance in the amelioration of nutrient, mineral and beta carotene
324 malnutrition in resource poor areas of developing countries.

326 4.2 Recommendation

A follow up study to assess the nutrient status of other varieties of sweet potato in the area and other factors such as phytochemicals, vitamins or their precursors will provide a full picture of the nutrient worth of the varieties of sweet potato grown in the study location.

4.0 References

1. Abubakar HN, Olayiwola IO, Sanni SA, Idowa MA. Chemical composition of sweet potatoes (*Ipomoea batatas* L am) dishes as consumed in Kware state, Nigeria. International Food Research Journal. 2010;17:411- 416.
2. Aywa AK, Nawiri MP, Nyambaka HN. Nutrient variation in coloured varieties of *Ipomea batatas* grown in Vihiga County, Western Kenya. International Food Research Journal. 2013;20(2):819-825.
3. Oduro I, Ellis WO, Owusu. Nutritional potential of two leafy vegetables: *Moringa oleifera* and *Ipomea batatas* leaves. Scientific Research and Essay. 2008;3:57-60.
4. Ofori G, Oduro I, Ellis WO, Dapaah H. Assessment of Vitamin A content and sensory attributes of new sweet potato (*Ipomea batatas*) genotypes in Ghana. African Journal of Food Science. 2009;3(7):184-192.
5. Meludu NT. Proximate analysis of Sweet potato toasted granules. African Journal of Biomedicine. 2010;13:89-91.
6. Ingabire MR, Vasanthakaalam H. Comparison of the Nutrient Composition of four sweet potatoes varieties cultivated in Rwanda. American Journal of Food and Nutrition. 2011;1(1):34-38.
7. Ukom AN, Ojmelukwe PC, Alamu EO. All trans-cis β -carotene content of selected sweet potato (*Ipomea batatas* (L) Lam) varieties as influenced by different levels of nitrogen fertilizer application. African Journal of Food Science. 2011;5(3):131-137.

8. Hue SM, Boyce AN, Chandran S. Antioxidant activity, phenolic and flavonoid contents in different varieties of sweet potato (*Ipomea batatas*). Australian Journal of Crop Science. 2012; 6(3):375-380.
9. Tierno R, Hornero-Méndez D, Gallardo-Guerrero L, López-Pardo R, Ruiz de Gallareta JI. Effect of boiling on the total phenolic, anthocyanin and carotenoid concentrations of potato tubers from selected cultivars and introgressed breeding lines from native potato species. Journal of Food Composition and Analysis. 2015;41:58–65.
10. Lachman J, Hamouz K, Orsák M, Kotíková Z. Carotenoids in potatoes – a short overview. Plant Soil Environment. 2016;62(10):474–481.
11. Mitra S. Nutritional Status of Orange-Fleshed Sweet Potatoes in Alleviating Vitamin A Malnutrition through a Food-Based Approach. Journal of Nutrition and Food Science. 2012;2:160. doi:10.4172/2155-9600.1000160.
12. FAOSTAT. 20016. Statistic Database (online) available online at <http://apps.fao.org>
13. FAOSTAT. 20017. Statistic Database (online) available online at <http://apps.fao.org>
14. Bidzakin JK, Acheremu K, Carey E. Needs Assessment of Sweet Potato Production in Northern Ghana: Implications for Research and Extension Efforts. ARPN Journal of Agricultural and Biological Science. 2014;9(9):315-319.
15. Sunette ML. Agronomic Performance, Consumer acceptability and nutrient content of new sweet potato varieties in South Africa. PhD thesis, University of Free state, South Africa. 2010;13-56.
16. Ghana Statistical Service (GSS). Population and Housing Census, Bolgatanga Municipality. 2010; 1-75.
17. Association of Official Analytical Chemist (AOAC). Official Method of Analysis, 16th edition, Washington DC; 2005.

18. Association of Official Analytical Chemist (AOAC). Official Method of Analysis, 16th edition, Washington DC; 2008.
19. Aweke A, Roba B. Evaluation of proximate composition of sweet potato [*Ipomoea batatas* (L.) Lam] for better utilization through agro-food processing chain. Global Journal of Animal Breeding and Genetics. 2016;4 (4):248-255.
20. Senanayake SA, Ranaweera KKDS, Gunaratne A, Bamunuarachchi A. Comparative analysis of nutritional quality of five different cultivars of sweet potatoes (*Ipomoea batatas* (L) Lam) in Sri Lanka. Food Science and Nutrition. 2013;1(4):284– 291.
21. Ukom A.N., Ojmelukwe P.C. and Okpara D.A. Nutrient composition of selected sweet potato [*Ipomoea batatas* (L) Lam] varieties as influenced by different levels of nitrogen fertilizer application. Pakistan Journal of Nutrition. 2009;8(11):1791-1795.
22. Hua J, Haixin Z, Hongtao L, Yunchao L. Analysis on the nutrition composition and antioxidant activity of different types of sweet potato cultivars. Food and Nutrition Sciences. 2015; 6:161-167. <http://dx.doi.org/10.4236/fns.2015.61017>.
23. Ellong EN, Billard C, Adenet S. Comparison of physicochemical, organoleptic and nutritional abilities of eight sweet potato (*Ipomoea batatas*) varieties. Food and Nutrition Science. 2014; 5(2):196-211.
24. Trinidad PT, Sagum RS, Mallillin AC, Borlagdan MS, de Leon MP, Aviles T. Sweet Potato and Cassava Can Modify Cholesterol Profile in Humans with Moderately Raised Serum Cholesterol Levels. Food Nutrition Science. 2013;4(5):491-495.
25. Sanoussi AF, Adjatin A, Dansi A, Adebawale A, Sanni LO, Sanni A. Mineral Composition of Ten Elites Sweet Potato (*Ipomoea Batatas* [L.] Lam.) Landraces of Benin. International Journal of Current Microbiology of Applied Science. 2016; 5(1):103-115.

Comment [SN23]: In the references section, the title of the article is written by using first letter in upper case alphabet for each word. Please follow the corrections made for references 22, 23, 24 etc., to correct the rest.