

Original Research Article

**Nutritional status of five sweet potato varieties grown in Bolgatanga
Municipality in the Upper East Region (UER) of Ghana.**

Abstract:

Aim: To grow five varieties of sweet potato together on the same beds under the same edaphic conditions to explore their respective nutrient, mineral, beta carotene and total carotenoid capabilities.

Study design: Vines of the various varieties were cultivated on 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 is 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. T.U. purple records the highest concentration of any mineral: 18250.70 ± 0.062 mg/kg of

Ca. 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. Zn occurs highest in

concentration of 123.12 ± 0.004 mg/kg in orange flesh variety and lowest (33.10 ± 0.002

mg/kg) in Agric white.

Concentration of beta carotene (mg/kg) in the 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 impregnated with macro- and micronutrients, beta carotene and total

carotenoids. T.U. purple variety is the richest source of Ca and beta carotene. The varieties of sweet potato may thus be of considerable importance in ameliorating nutrient, mineral as well as beta carotene malnutrition in resource poor areas of developing countries.

Key words: sweet potato varieties, Agric white, Red skin, Orange flesh, T.U. purple, nutrient, minerals, beta carotene.

1.0 Introduction

1.1 Background:

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

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

Recent world statistical data [12] put China as the country producing the highest tonnage of sweet potatoes of 70,526,000 metric tons per year, which constitute far more than half (68.6%) of total global production. Tanzania and Nigeria follow in that order with 3,470,304 metric tons and 3,450,000 metric tons respectively, each sharing a proportion of 3.3% of world production. Indonesia and Uganda are fourth and fifth in the world in terms of sweet potato cultivation, contributing a combined 4% of total production.

Ghana produced 143,111 tons of sweet potatoes in 2016 from an area covering 76,594 ha of land. This constituted a share of 0.1% of total potato production in the world that year and ranked Ghana at number 37 in the world with respect to sweet potato production [13]. The data show that the production of the crop in Ghana has increased in a decade, given that earlier records, posted a production of 90,000 tons from an area of 65,000 ha ([12] [14]). Bidzakin and coworkers [14] also cited Ministry of Food and Agriculture (MoFA) Field survey in 2012 to have reported that in Ghana, Upper East is the Region with the highest sweet potato cultivation, producing 46,000 metric tons, being 34.9% of total production in Ghana, from an area of land covering 5,550 ha, which is 57.7% of total land used for the production of the crop in Ghana. Northern and then Upper West regions follow in that order with respect to both the area of land devoted to potato production and the tonnage produced per annum.

However, data from the Upper East Regional Office of the Ministry of Food and Agriculture (MoFA) show a steady decline in the production of sweet potatoes from 2008 to 2017, after a steep rise in production from 2007 to 2008 (Figure 1).

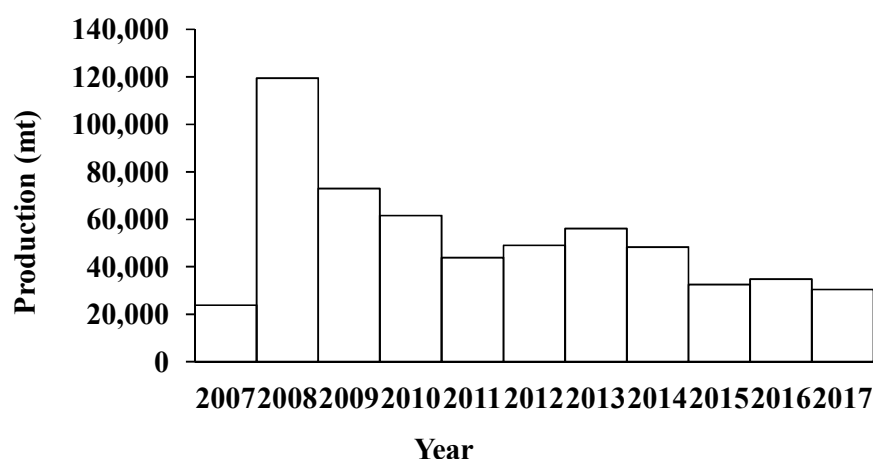


Figure 1: Annual production of sweet potatoes in metric tons (mt) from 2007 to 2017.

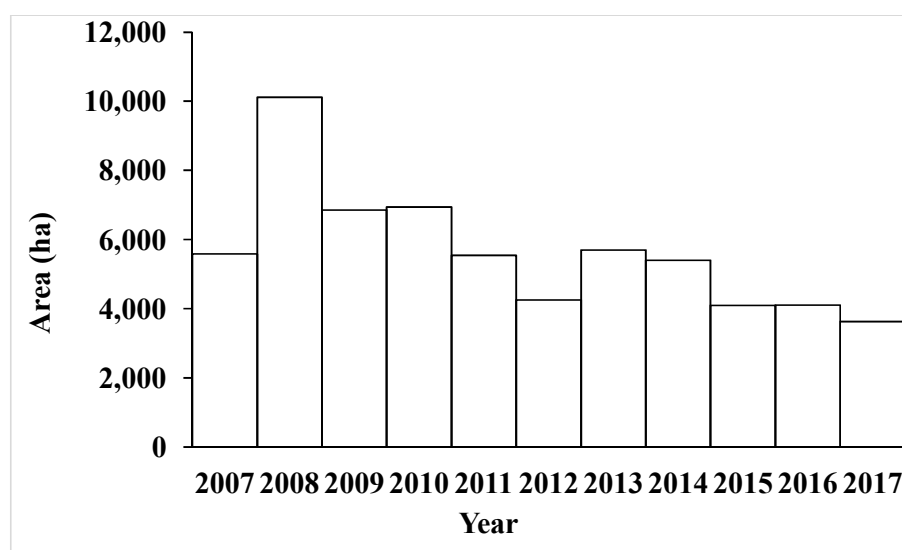


Figure 2: Area of land (ha) used in the production of sweet potatoes from 2007 to 2017

The data also show that farmers progressively devoted less land for the cultivation of the crop (Figure 2). Farmers in this region were reported to have complained of the absence of planting materials like sweet potato seeds, farm inputs and implements as well as a ready market to purchase their farm produce as being obstacles to increasing the productivity of sweet potatoes [14]. This may account for the increasing loss of interest in cultivating the

crop. Though providing the above inputs to farmers may improve production, it is also thought that determining the nutrients available in the crop may encourage the consumption of the crop to increase the demand for the crop thereby enhancing market and increasing sweet potato production. Various works have investigated and reported the nutrient contents of different varieties of the crop. However, it has been established that the type and concentration of macro- or micronutrients as well as other phytochemicals in any given crop is dependent on the respective availability and concentration of the same in the soil on which the crop is grown ([1]; [5]; [15]; [6]; [7]; [2]). Thus the same crop grown in different geographic regions may be biofortified with different concentrations of the same or different elements all together. Therefore it is necessary for crops grown in different geographic locations to be analysed to ascertain their nutrient worth and biofortification with vitamins or minerals which have health benefits. However, the nutrient content of different varieties of a crop can be compared when they are cultivated at the same location with similar soil conditions. The study seeks to find out the proportions of food substances such as crude protein, carbohydrates and fat; total carotenoids and beta carotene as well as some major and minor minerals that reside in the sweet potatoes grown in parts of the upper East Region.

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101 **2.0 Methodology**

102 **2.1 The study site:**

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

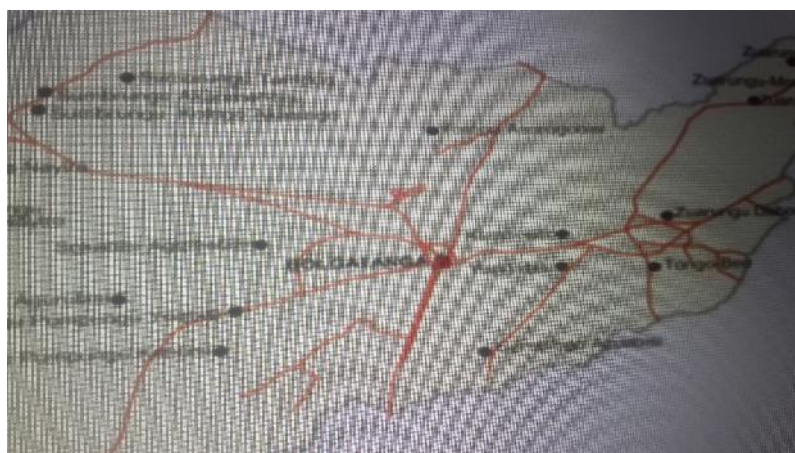


Figure 3: Map of Bolgatanga Municipality.

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 vulgaris* (sorghum), *Oryzae sativa* (rice), *Arachis hypogaea* (groundnuts), *Phaseolus vulgaris* (beans) and *Ipomea batatas* (sweet potatoes) during the rainy season. However, in the dry season, *Lycopersicum esculentum* (tomatoes), *Allium cepa* (onions) as well as *Oryzae 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 Blogatanga and other farms in Sumbrungu (Orange flesh, Red skin, T.U. purple).

2.3 Cultivation of sweet potato varieties

These vines were then cultivated in Dukumah Garden, on parallel lines on the same bed so that their performance with respect to nutrient content can be compared. The same organic manure was applied evenly to all lines. No synthetic fertilizer was applied.

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 sent personally to the Food Chemistry laboratory of Kwame Nkrumah University of Science and Technology for the following analysis:

- 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

The samples were each 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).

3.0 Results

3.1 Colours of the different varieties:

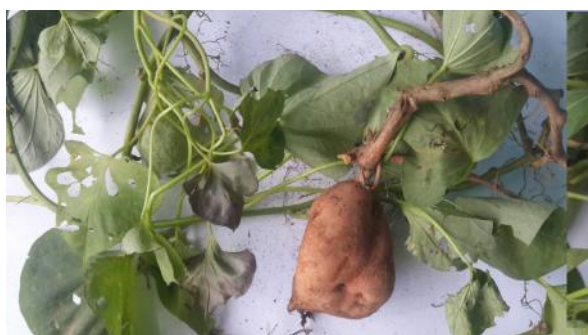
151 The colours of the five different varieties of sweet potatoes (shown with their vines in plates
152 1 to 5), grown in the Bolgatanga Municipality which have been analysed are as follows:
153 Three varieties are coloured. They include Agric orange flesh and Orange flesh which are
154 much alike, having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



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158 **Plate 1: Agric orange flesh Plate 2: Agric white Plate 3: Red skin**

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161 **Plate 4: Orange flesh Plate 5: T.U. purple**

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3.2 Proximate analysis:

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

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

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

NFE: nitrogen free extract, TC: total carbohydrates.

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

	Concentration in mg/kg					
SPV	Mg	Na	K	Ca	Fe	Zn
AO	13322.4	2810.54	4444.77	6282.49±	38.47±	36.49±0.

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

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

The study determined the concentration of four major minerals: magnesium (Mg), sodium (Na), potassium (K), calcium (Ca) and two minor ones: iron (Fe) and zinc (Zn). The results of analysis of varieties of sweet potatoes for minerals are shown in table 2. All five varieties of sweet potatoes contain these elements in varying concentrations in milligrams per kilogram (mg/kg). For instance, all the five sweet potato varieties contain Mg in appreciably high concentrations. However, of all the five sweet potato varieties studied, T.U. purple recorded the highest concentration of any mineral than the other varieties: 18250.70±0.062 mg/kg of Ca. The rest of the varieties recorded moderate concentrations of Ca. Again, all varieties contained low concentrations of Na and K, all be it, the latter in relatively higher concentration than the former. The T.U. purple, red skin and orange flesh varieties contained comparatively higher concentrations of the two minor minerals (Fe and Zn) than the Agric orange flesh and Agric white varieties.

The orange flesh (OF) variety has the highest concentration in milligrams per kilogram (mg/kg) of Mg (13713.44 ± 0.069), K (5265.03 ± 0.023) and Zn (123.12 ± 0.004), but has the lowest concentration of Na (1669.88 ± 0.051 mg/kg). The Red Skin (RS) variety has the second highest concentration in mg/kg of the minor minerals: Fe (85.91 ± 0.007) and Zn (105.18 ± 0.001) while the Agric orange flesh (AO) has that of Mg (13322.44 ± 0.098) and Ca (6282.49 ± 0.200). On the other hand, the Agric white (AW) variety has the second highest concentration in mg/kg of K (4882.07 ± 0.078). The T.U. purple (TP) variety has the highest concentration in mg/kg of Fe (101.33 ± 0.007) and Ca (18250.70 ± 0.062). The Agric white variety is found to have the lowest concentration in mg/kg of the trace minerals: Fe (7.71 ± 0.003) and Zn (33.10 ± 0.002) 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 red skin variety.

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.

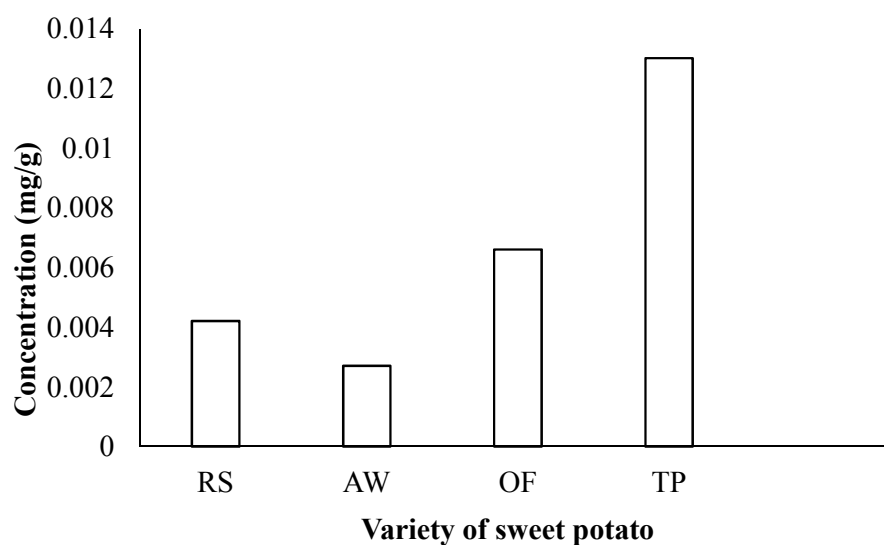


Figure 5: Beta carotene concentration (mg/g) in varieties of sweet potatoes

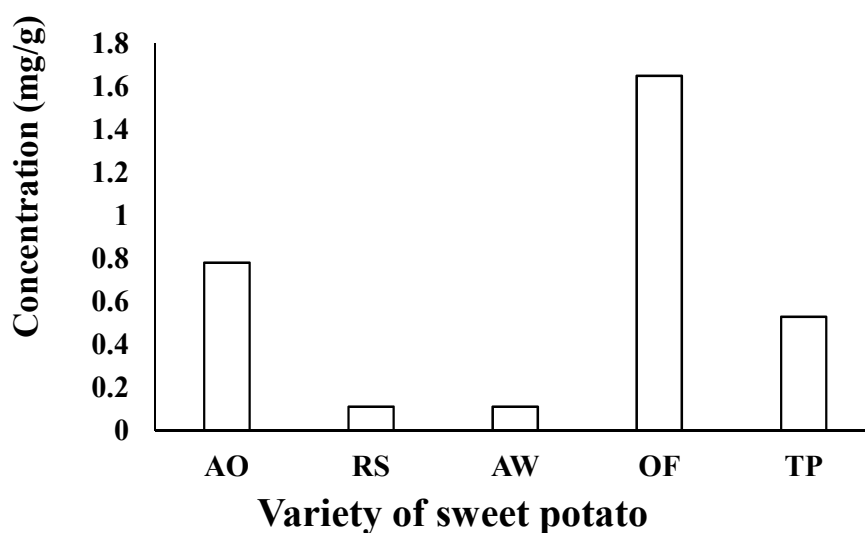


Figure 6: Total carotenoids concentration (mg/g) in varieties of sweet potatoes

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 fleshed ones. The range of protein content found here is not much different from the range of 3.3% to 1.2% reported of five varieties in Sri Lanka [20]. It is however, much higher than the range of 0.91% to 0.05% reported in Rwanda [6]. The current finding of protein range is however, lower than the range of protein content from 4.16% to 3.28 recorded in Nigeria [21]; 6.53% to 4.86% reported in China [22] and the range of 4.09 to 1.97% reported in Benin [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. Aweke and Roba [19] recorded a much higher range of fat content ($8.88 \pm 0.30\%$ to $0.54 \pm 0.13\%$) in Benin. 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 in Rwanda [6]; but much lower than the range of 2.35% to 1.85% reported in China [8]; the range of 13.60% to 2.10% found in Sri Lanka [20]; the range of 5.40 to 3.30%

251 in Martinique [23] as well as the range of 3.00 to 1.81% [19] in Benin. Foods rich in crude
252 fibre may reduce the likelihood of one experiencing various sicknesses such as those related
253 to the digestive system; sugar related health issues as well as heart problems ([6]; [24]).

254 Total carbohydrate content in the varieties of sweet potato studied was also found to range
255 from 23.2% in the Agric orange flesh variety to 15.8% in Agric white one, which is lower
256 than the range (38.92 ± 0.04 to $14.46 \pm 0.07\%$) found by Aweke and Roba in Benin[19]. Thus,
257 sweet potato cultivating rural folks of developing countries have access to cheap but good
258 source of calories in this crop.

259 A moisture content ranging from 75.78% in the Agric white variety to 71.04% in the Orange
260 flesh one, was also found, which is higher than the finding of a range between 64.34% to
261 62.58% [6] in Rwanda as well as 70.0% to 61.00% [21] in Nigeria. This shows that the five
262 sweet potato varieties all have very high moisture content. This may impact on taste when
263 freshly harvested sweet potatoes are cooked immediately. The averagely high moisture
264 contained in the five varieties may account for the general low ash content, given that the
265 orange flesh variety which recorded the lowest moisture of 71.04% has the highest ash
266 content of 1.56%. According to Ingabire and Vasanthakaalam [6], high moisture in sweet
267 potatoes is the cause of their low ash content.

268 The study determined that all five varieties of sweet potato contain varying concentrations of
269 Mg, Na, K, Ca, Fe and Zn. The highest concentration of Mg (13713.44 ± 0.069 mg/kg) was
270 found in the orange flesh (OF) variety whereas its lowest concentration (9651.17 ± 0.017
271 mg/kg) was recorded in the red skin variety. Mg occurs in high concentration in all five
272 varieties of sweet potato in this study. Thus any of the five varieties is a good source of this
273 major mineral. A recent study in Bennin [25] reported a lower concentration range of Mg of
274 (2540.00 to 2130.00 mg/kg) than that of the current study.

275 Of the four major minerals studied, the Na concentration is the lowest recorded in all five
 276 sweet potato varieties with an average of 2044.29 mg/kg. This concentration of Na is lower
 277 than the range of 3400.00 to 2900.00 mg/kg reported in Bennin [25].

278 The concentration of K is low in all five sweet potato varieties, averaging 4537.11 mg/kg,
 279 though this is more than twice the average concentration of Na. Thus, these sweet potato
 280 varieties may not be rich sources of K and Na, more so, the latter. This low range of K
 281 concentration is much lower than that reported in Western Kenya (16838.00-1040.00 mg/kg)
 282 [2] and in Bennin of 32867.00 to 30867.00 mg/kg [25].

283 The highest concentration in mg/kg of Ca (18250.70 ± 0.062 and Fe (101.33 ± 0.007) were
 284 found in the T.U. Purple (TP) variety with the lowest concentration of Ca (3944.48 ± 0.126)
 285 and Fe (7.72 ± 0.003) recorded in the red skin (RS) and Agric white (AW) varieties
 286 respectively. The highest concentration in mg/kg of Ca (18250.70 ± 0.062) in the T.U. purple
 287 variety (TP) is the highest concentration of all the minerals found. T.U. purple (TP) therefore,
 288 is the richest source of Ca, out of the five varieties. On the other hand, the concentrations of
 289 Fe in the sweet potato varieties decreases in the order: TP>RS>OF>AO>AW. The Ca
 290 concentrations recorded in this work is much higher than that recorded by Senanayake et al.
 291 in Sri Lanka of Ca (590.00 to 210.00 mg/Kg) [20]. However, their report of Fe concentration
 292 of 630.00 to 420.00 mg/Kg, is much higher than found in this work. In a similar vein, the Ca
 293 concentration recorded in the current study is much higher than the concentration range of
 294 2735.00 to 1850.00 mg/kg in varieties of sweet potato reported [2] in Western Kenya while
 295 their Fe concentration of (140.00-103.00 mg/kg) is higher than that found in this study.

296 Again, the current finding shows higher concentration ranges of these minerals than that
 297 found in Bennin [25] of 2997.00 to 2304.00 mg/kg for Ca and 73.00 to 53.00 mg/kg for Fe.
 298 Zn was recorded highest in concentration of 123.12 ± 0.004 mg/kg in the orange flesh (OF)
 299 variety and lowest (33.10 ± 0.002 mg/kg) in the Agric white (AW) variety. Similarly, the

concentrations of Zn in the sweet potato varieties decreases in the order: OF>RS>TP>AO>AW. This concentration range of Zn is much higher than the range of 27.00 to 23.00 mg/kg recorded in Benin recently [25].

The concentration of beta carotene (mg/kg) in the five sweet potato varieties increases in the order AO<<AW<RS<OF<TP, where the highest concentration of 0.0130 mg/kg was recorded in the T.U. purple variety while the lowest concentration of 0.0009 mg/kg was recorded in the Agric orange flesh variety. An earlier study [21] found beta carotene content to range from 0.0071 to 0.0060 mg/kg in Nigeria, which is within the current record. The all-white variety (Agric white) contained 0.0027 mg/kg as the red skinned but white fleshed variety recorded 0.0042 mg/kg of beta carotene, contrasting differently from earlier findings of no beta carotene at all in white sweet potato varieties ([6]; [2]). In this study, T.U. purple (TP) is the variety that may be recommended as a beta carotene supplementary food, well ahead of the orange flesh (OF) variety.

However, in keeping with these earlier reports ([6]; [2]), the two white fleshed varieties (AW and RS) recorded the lowest concentration of total carotenoids of 0.11 mg/kg each while the Orange flesh (OF) variety has the highest content of 1.6454 mg/kg.

Given that all the varieties were cultivated on the same beds with the same soil type, soil nutrient content and moisture, their levels of nutrient fortification can be attributed solely to the variety of sweet potato and not variation in the soil type ([1]; [5]; [15]; [6]; [7]; [2]).

4.1 Conclusion

The five varieties of sweet potato are not only rich to varying degrees in proteins, carbohydrates, fats and oils, but are also impregnated with both macro- and micronutrients, beta carotene and total carotenoids. The highest sources of protein and fat are Agric white and orange flesh varieties respectively whereas the Agric orange flesh variety contains the

greatest proportions of both total carbohydrate and crude fibre. All varieties contain high amounts of Mg. The T.U. purple variety is the richest source of Ca and beta carotene, well ahead of the rest. All the varieties of sweet potato contain moderate and low concentrations of K and Na respectively. The varieties of sweet potato may thus be of considerable importance in the amelioration of nutrient, mineral as well as beta carotene malnutrition in resource poor areas of developing countries.

4.2 Recommendation

A follow up study to assess the nutrient status of other varieties of sweet potato in the area as well as 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 there.

4.0 References

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