The Nutritive Quality and Antioxidant Activity of Some Vegetable Soups During Frozen Storage

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ABSTRACT

***Background:** Storage of soups at -18 ℃ are used to preserve and avoid nutritional losses which may arise as a result of periodical heating. Unfortunately, continuous supply of electricity is not always available to majority of Nigerian homes resulting to an adverse loss of soup quality due to several thaw cycles.*
***Objective:** To evaluate the nutritive composition and antioxidant activity of some vegetable soups during frozen storage.*
***Materials and Methods:** Ugu (TVS) and oha (PVS) vegetable soups were prepared with some other ingredients. Standard methods were used to evaluate the nutritive composition and antioxidant activity of the soups during frozen storage.*
***Results:** The results showed that the proximate values of TVS soup: fat (15.15 – 15.80%), fibre (13.00 – 13.80%), protein (17.15 – 18.30%), and ash contents (10.70 – 10.90%) were significantly ($p<0.05$) higher than the fat (10.70- 11.60%), fibre (9.00 – 9.80%), protein (15.35 – 16.0%), and ash contents (8.90 – 9.60%) of PVS soup. Minerals (Mg, P, Zn, Fe) and vitamins (A and E) followed the same trend. However, there was stronger scavenging power of %DPPH, ABTS and FRAP in PVS than TVS soup. %DPPH, ABTS and FRAP values were 60.86 – 62.04%, 26.42 – 27.52 mg/GAE/g, and 20.02 – 20.63 µmolTE/g in PVS soup, whereas, that of TVS soup were 37.68 – 43.12%, 3.04 – 3.75 µmolTE/g, and 8.26 – 10.43 mgGAE/g. It was observed that polyphenols and vitamin C contributed to strong DPPH, ABTS, and FRAP scavenging activity.*
***Conclusion:** The soups can serve as functional food, improve nutrition and the boosting of physiological health to consumers.*

Keywords: Vegetable soups; Nutritive quality; Antioxidant compounds; Antioxidant activity; Storage at -18 ℃

INTRODUCTION

Soup is a major food supplement that is utilized by millions of households on a daily basis in the West African region. Soups are liquid food that are generally served warm or cold. They are cooked by combining ingredients like meat, fish, vegetables, thickeners and water until the flavors are extracted for a desired taste. They may be clear or thick soups (1). West African countries are a multi -cultural society with different traditional soups prepared from different ingredients and vegetables. Soups contain nutrients that not only promote proper physical growth and development, but also ensure adequate immune competence (2). Most indigenous West African soups have a water base that is thickened with a variety of cereal and legume flours like groundnut, melon seed (*egusi*) and *ogbono*, yam and cocoyam or cassava flours (1).

Soups are rich and nutritious because they contain fish, meat, crayfish, vegetables and other

ingredients (3). They provide protein from meat and fish stock, vitamins, minerals and phytochemical compounds from vegetables. FIIRO (4) had reported on the mineral composition of some soups common to Nigeria. Phytochemical compounds contained in vegetables like carotenoids and polyphenols are some important dietary antioxidants for human wellness. Antioxidants are compounds that prevent certain types of chemical damage caused by an excess of free radicals generated by aerobic metabolism (5). Antioxidants have the ability to scavenge free radicals and help to fight against degenerative diseases like cancer, heart disease, stroke, and other immune compromising diseases (6).

For many households, soups are prepared and eaten immediately. In spite of economic burden, general sedentary work life and burdensomeness of soup preparation and serving, some households without the means of preservation prepare soups once a week and reheat daily to prevent microbial spoilage. This method of utilization of soups have been reported to result in loss of vitamins and other nutritive benefits (7). However, in some homes and mostly in urban cities with National or personal electricity generation, storage of soups at – 18 ^{0}C are used to preserve and avoid flavor changes and nutritional losses which may arise as a result of periodical heating (7). Preservation of soups by storage at – 18 ^{0}C can retain the nutritive quality and sensory attributes by reducing or preventing microbial contamination and deterioration of soups by oxidation. This method of soup preservation is time saving and economical especially for urban dwellers and workers who use freezers. Unfortunately, electricity supply to homes for a continuous storage at – 18 ^{0}C is not applicable to majority of the urban population in Nigeria. This may have adverse effect on the soup quality due to several thaw cycles.

Soups are prepared with vegetables and some other ingredients. Some of the vegetables commonly used in preparing soups are fluted pumpkin, waterleaf, *oha* leaf , okra, *Amaranthus hybridus, Gnetum africanum,* and many others. Till date, there are scarce reports on the nutrient quality and antioxidant activity of storage of vegetable soups at – 18 ^{0}C as practised by several housholds. In this study, two types of vegetable soups, their nutrient qualities and antioxidant potentials were evaluated during eight days of storage at – 18 ^{0}C.

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MATERIALS AND METHODS

Raw material collection

The vegetables and other ingredients used for the soups preparation were obtained in Umudike area, Ikwuano LGA, Abia State in Southeast, Nigeria. Freshly harvested *ugu* (*Telferia occidentalis)*, waterleaf (*Talinium triangulare*) and *oha* (*Pterocarpus mildraedii)* leaves were packaged in a black polyethylene container and stored in the refrigerator at 4 ^{0}C for 15 h to prevent wilting and enzymatic actions before subsequent use. The vegetables were washed in potable water to remove adhering soil. The vegetables were separately handpicked from the nodes and shredded using stainless steel kitchen knives and weighed.

Preparation of soups

Ugu (Telferia occidentalis) soup (TVS) was prepared with 129.76g of beef that was previously boiled for 30 min. Two hundred ml of potable water, 99.50g smoked fish, 85g fresh palm oil were added to the pot and boiled for further 10 min. Later, 4.38g ground pepper, 16.19g magi, 10.03g table salt, 9.30g crayfish, 400g *ugu* (*Telferia occidentalis)* and 200g water leaves (*Talinium triangulare*) were added, mixed and boiling continued for another 5 min. The soup was made ready and allowed to cool to 10^{0}C. Sample at zero day was taken for nutrients determination and the rest was put in four different sterilized plastic containers and stored in the freezer (Haier Thermocool HTF-319H, Nigeria) for subsequent analysis.

Oha (Pterocarpus mildraedii) soup (PVS) was prepared with 129.76g of beef that was previously boiled for 30 min. Then 350ml of potable water, 99.50g smoked fish, 225.03g boiled and pounded cocoyam paste (thickener), 85g red palm oil were added to the pot and boiled for 10 min. Then, 4.38g pepper, 16.19g magi, 9.30g crayfish, 7.72g *ogiri* (condiment), 100.81g *Pterocarpus mildraedii* leaves were added and boiled further for 5 min. The soup was ready and allowed to cool to 10^{0}C. At zero day, the soup was scooped for nutrient analyses and the remaining was distributed in four sterilized plastic containers, stored in the freezer (Haier Thermocool HTF-319H, Nigeria) for subsequent analyses.

These soups were made according to desired consistency. For example, 200ml and 350ml of potable water was used for *ugu* and *oha* soups during preparation. *Ugu* and waterleaf released water into the soup, while cocoyam paste

thickened the *oha* soup.

Determination of the proximate composition of soups

The proximate composition of the soups were determined according to the method of AOAC (8). The moisture content was determined by the hot air oven (DHG9053A, England) method for 4 h at 10^{0}C. The ash content was determined by the Muffle furnace (SX2-2.5-12NP, China) at 550^{0}C for 4 h. The percentage protein content was determined in three stages: digestion, distillation and titration by the Kjeldahl method (nitrogen content multiplied by 6.25). The fat content was determined by continuous petroleum ether extraction in Soxhlet apparatus with 200ml of petroleum ether (boiling point 40-60^{0}C) for 4h. The crude fibre was estimated by the gravimetric method and the carbohydrate content was calculated by difference.

Determination of the minerals and vitamins contents of the soups

Zinc and iron were determined by the method of James (9). Calcium and magnesium were determined by EDTA Versanate complexometric method of James (9). Sodium and potassium were determined by a serial dilution of Na or K solution of 0, 2, 4, 6, 8 and 10 ppm by flame photometry (Jenway Digital Flame Photometer, England) according to the method of Carpenter & Hendricks (10). Vitamins A and E were determined by the method described by Nielsen (11) with some modifications using UV-VIS spectrophotometer (Jenway electronic spectrophotometer, England).

Determination of the bioactive compounds and antioxidant activity of the soups

Total polyphenol and flavonoids contents were determined by the method described by Jagadish *et al*. (12). Gallic acid was used as standard for the calibration curve for total polyphenol and the result recorded as mg GAE/gfw. Flavonoids content was determined by $AlCl_3$ method and the standard calibration curve was prepared from quercetin. The flavonoids content was expressed as mg Q/gfw.

$ABTS^{\cdot+}$ was determined according to the method of Seeram *et al*. (13). ABTS+ value was calculated from Trolox standard curve and expressed as Trolox Equivalent in μM.

The DPPH radical scavenging activity of the soups was determined by the method described by Manzocco *et al* (14). The percentage of the DPPH radical scavenging activity was calculated using the equation: %Inhibition of DPPH radical = $(A_o - A_s)/Ao \times 100$; Where A_o = absorbance of the control reaction containing all reagent except test sample, A_s = absorbance of the soup. The FRAP antioxidant assay was measured by the method developed by Benzie & Strain (15).

Statistical analysis

The mean and standard deviation were calculated in triplicate with a computer software SPSS Version 10 (SPSS, Inc., Chicago, USA). Data were expressed as mean ± standard deviation (SD). Comparisons were performed with analysis of non-parametric test. A value of $p < 0.05$ was considered statistically significant.

RESULTS

Proximate composition of the vegetable soups

Table 1 shows the macro-nutrient contents of the soups from 0 to 8th days of frozen soup. The results showed that the proximate contents of TVS soup was significantly ($p<0.05$) higher than the values of PVS soup. The nutrient values for TVS soup ranged for moisture (6.70 – 7.60%), fibre (13.00 – 13.80%), fat (15.15 - 15.80%), protein (17.15 - 18.30%), carbohydrate (35.30 – 35.90%), and ash contents (10.70 – 10.90%), whereas, PVS soup had for moisture (6.40 to 7.30%), fat (10.70 – 11.60%), protein (15.35 - 16.00%), ash (8.90 – 9.60%), fibre (9.00 – 9.80%). However, the carbohydrate content of PVS soup (47.40 – 48.25%) was signicantly ($p<0.05$) higher than that of TVS soup.

Minerals and vitamins content of soups

The minerals content of the soups are shown in Table 2. Minerals content showed significant ($P<0.05$) decrease in both soups during the storage from 0 to 8th days. The minerals concentrations in TVS soup ranged as follows: Ca (46.07 – 48.38 mg/100g), Mg (67.86 – 68.81 mg/100g), Zn (8.13 – 9.26 mg/100g), P (405.47 – 407.25 mg/100g) and Fe (8.48 – 9.55 mg/100g), while vitamins A and E were (21.29 – 24.22

Table 1: Proximate composition of frozen soups from 0 to 8 days of storage (% dw)

Storage time (Days)	Soup type	MC	CF[1]	CF[2]	CP	CHO	Ash
0	**TVS**	$6.70^{c} \pm 0.14$	$15.80^{a} \pm 0.28$	$13.00^{b} \pm 0.28$	$18.30^{a} \pm 0.14$	$35.30^{a} \pm 0.71$	$10.90^{a} \pm 0.14$
	PVS	$6.40^{c} \pm 0.00$	$11.60^{a} \pm 0.28$	$9.00^{a} \pm 0.57$	$16.00^{a} \pm .35$	$47.40^{a} \pm 0.64$	$9.60^{a} \pm 0.14$
3	**TVS**	$7.10^{b} \pm 0.14$	$15.70^{ab} \pm 0.14$	$13.00^{b} \pm 0.00$	$18.00^{a} \pm 0.00$	$35.40^{a} \pm 0.28$	$10.80^{a} \pm 0.28$
	PVS	$6.70^{bc} \pm 0.14$	$11.30^{ab} \pm 0.14$	$9.10^{a} \pm 0.14$	$15.92^{a} \pm 0.11$	$47.58^{a} \pm 0.32$	$9.40^{ab} \pm 0.00$
5	**TVS**	$7.60^{a} \pm 0.00$	$15.40^{ab} \pm 0.00$	$13.30^{b} \pm 0.14$	$17.50^{b} \pm 0.14$	$35.35^{a} \pm 0.21$	$10.85^{a} \pm 0.07$
	PVS	$7.30^{a} \pm 0.14$	$11.00^{bc} \pm 0.00$	$9.40^{a} \pm .0.00$	$17.0^{ab} \pm 0.00$	$47.50^{a} \pm 0.00$	$9.10^{bc} \pm 0.14$
8	**TVS**	$7.30^{ab} \pm 0.14$	$15.15^{b} \pm 0.07$	$13.80^{a} \pm 0.00$	$17.15^{c} \pm 0.14$	$35.90^{a} \pm 0.07$	$10.70^{a} \pm 0.00$
	PVS	$7.00^{ab} \pm 0.28$	$10.70^{c} \pm 0.14$	$9.80^{a} \pm 0.00$	$15.35^{b} \pm 14$	$48.25^{a} \pm 0.14$	$8.90^{c} \pm 0.14$

Values are means ± standard deviation of duplicate determinations. Means of the same soup (TVS or PVS) with the same superscripts within the columns are not significantly ($p>0.05$) different. Key: TVS = Telferia occidentalis vegetable soup, PVS = Pterocarpus mildraedii vegetable soup, MC = Moisture content, CF[1] = Crude fat, CF[2] = Crude fibre, CP = Crude protein, CHO = Carbohydrate

Table 2: Minerals and vitamins profiles of frozen soups from 0 to 8 days of storage (mg/100g dw)

Storage time (Days)	Soup Type	Ca	Mg	Zn	P	Fe	Vit.A (µg/100g)	Vit. E (µg/100g)
0	**TVS**	$48.38^{a} \pm 0.39$	$68.81^{a} \pm 0.54$	$9.26^{a} \pm 0.00$	$407.24^{a} \pm 1.34$	$9.55^{a} \pm 0.44$	$24.22^{a} \pm 0.14$	$26.67^{a} \pm 0.31$
	PVS	$104.9^{a} \pm 0.44$	$47.24^{a} \pm 0.49$	$6.10^{a} \pm 0.45$	$288.92^{a} \pm 1.05$	$5.11^{a} \pm 0.30$	$18.07^{a} \pm 0.26$	$21.46^{a} \pm 0.00$
3	**TVS**	$47.99^{a} \pm 0.47$	$68.79^{a} \pm 0.00$	$8.63^{b} \pm 0.25$	$406.82^{a} \pm 0.52$	$9.15^{ab} \pm 0.11$	$23.39^{a} \pm 0.37$	$25.41^{b} \pm 0.25$
	PVS	$104.40^{ab} \pm 0.29$	$46.38^{ab} \pm 0.29$	$5.70^{ab} \pm 0.29$	$287.77^{ab} \pm 0.84$	$4.92^{ab} \pm 0.17$	$17.02^{b} \pm 0.08$	$19.94^{b} \pm 0.42$
5	**TVS**	$46.77^{b} \pm 0.53$	$68.16^{a} \pm 0.16$	$8.32^{bc} \pm 0.00$	$406.68^{a} \pm 0.00$	$8.75^{b} \pm 0.16$	$22.33^{b} \pm 0.60$	$24.66^{c} \pm 0.00$
	PVS	$103.42^{bc} \pm 0.65$	$46.09^{b} \pm 0.00$	$5.51^{ab} \pm 0.16$	$286.76^{b} \pm 0.37$	$4.64^{ab} \pm 0.00$	$16.02^{c} \pm 0.24$	$18.98^{c} \pm 0.33$
8	**TVS**	$46.07^{b} \pm 0.00$	$67.86^{a} \pm 0.37$	$8.13^{c} \pm 0.09$	$405.47^{a} \pm 0.43$	$8.48^{b} \pm 0.15$	$21.29^{c} \pm 0.00$	$23.67^{d} \pm 0.32$
	PVS	$102.80^{c} \pm 0.00$	$45.61^{b} \pm 0.45$	$5.16^{b} \pm 0.11$	$286.12^{b} \pm 0.00$	$4.43^{b} \pm 0.20$	$14.85^{d} \pm 0.00$	$18.10^{d} \pm 0.11$

Values are means ± standard deviation of duplicate determinations. Means of the same soup (TVS or PVS) with the same superscripts within the columns are not significantly ($p>0.05$) different. Key: TVS = Telferia occidentalis vegetable soup, PVS = Pterocarpus mildraedii vegetable soup, Ca = Calcium, Mg = Magnesium, Zn = Zinc, P = Potassium, Fe = Iron, Vit. A = Vitamin A, Vit. E = Vitamin E

Antioxidants contents of soups

Total flavonoids, total phenol and vitamin C contents of the soups are shown in Table 3. Results were recorded only at the 0 and 8 day of storage at – 18 ^{0}C. The antioxidants results varied significantly at $p<0.05$. Flavonoids content of TVS soup ranged from 4.15 – 3.83 mgQE/g. Flavonoids content was higher at 0 than 8th day of storage at – 18 ^{0}C. Although, total polyphenol was insignificant in both soups ($p>0.05$) irrespective of the storage days, there ranged from 16.01 to 21. 64 (mgGAE/g. Vitamin C contents ranged from 14.82 – 21.64 mg/100g. Total polyphenol and Vitamin C contents were higher in PVS soup than TVS soup.

Antioxidant activity of soups

The antioxidant activity of the soups is shown in Table 4. Antioxidant activity were determined only at 0 and 8 day of storage. The results showed significant ($p<0.05$) variations between the two soups. The PVS soup recorded the highest %DPPH

of 62.04 and 60.86% in 0 and 8th day. The same trend was observed in FRAP values, which reduced from 27.52 to 26.42 mgGAE/g, and from 20.63 to 20.02 μmolTE/g for ABTS at 0 and 8th day. The same downward trend was observed in the antioxidant activity of TVS soup which also reduced for %DPPH (43.12 to 37.68%), FRAP (10.43 to 8.26 mgGAE/g), and ABTS (3.75 to 3.04 μmol/TE/g) in 0 and 8 day of storage at – 18 °C.

Table 3: Antioxidants contents of frozen soups from 0 and 8th days of storage (dw)

Soups	TF (mgQE/g)	TP (mgGAE/g)	Vit. C (mg/100g)
TVS[1] (0 day)	$4.15^{a}\pm0.01$	$16.02^{b}\pm0.02$	$16.47^{c}\pm0.03$
PVS[1] (0 day)	$4.02^{b}\pm0.01$	$21.64^{a}\pm0.02$	$21.64^{a}\pm0.02$
TVS[2] (8th day)	$3.92^{c}\pm0.02$	$16.01^{b}\pm0\ 01$	$14.82^{d}\pm0.01$
PVS[2] (8th day)	$3.83^{d}\pm0.01$	$21.31^{a}\pm0.01$	$17.53^{b}\pm0.03$

Values are mean ± SD analyzed in duplicate. Mean values in the column with different superscript are significantly different at (p<0.05). Key: TVS[1] = Fresh Telferia occidentalis vegetable soup, PVS[1] = Fresh Pterocarpus mildraedii vegetable soup, TVS[2] = Stored Telferia occidentalis vegetable soup, PVS[2] = Stored Pterocarpus mildraedii vegetable soup, TF = Total flavonoids, TP = Total polyphenols, Vit. C = Vitamin C.

Table 4: Antioxidant activity of frozen soups at 0 and 8 days of storage

Soup	DPPH (%Inhibition)	FRAP (mgGAE/g)	ABTS (μmol/TE/g)
TVS1 (0 day)	$43.12^{c}\pm0.03$	$10.43^{c}\pm0.14$	$3.75^{c}\pm0.28$
PVS1 (0 day)	$62.04^{a}\pm0.4$	$27.52^{a}\pm0.02$	$20.63^{a}\pm0.01$
TVS2 (8th day)	$37.68^{d}\pm0.01$	$8.26^{d}\pm0.01$	$3.04^{d}\pm0.02$
PVS2 (8th day)	$60.86^{b}\pm0.02$	$26.42^{b}\pm0.02$	$20.02^{b}\pm0.01$

Values are mean ± SD analyzed in duplicate. Mean values in the column with different superscript are significantly different at (p<0.05). Key: DPPH = 2, 2-diphenyl-1-picrylhydrazyl, FRAP = Ferric ion reducing antioxidant power, ABTS = 2, 2' azinobis-3-ethylbenzthiazoline-6-sulphonic acid assay, TVS1 = Fresh Telferia accidentalis vegetable soup, PVS1 = Fresh Pterocarpus mildraedii vegetable soup, TVS2 = Stored Telferia accidentalis vegetable soup, PVS2= Stored Pterocarpus mildraedii vegetable soup.

Pearson correlation coefficient of antioxidants and antioxidant activity of soups

The Pearson correlation coefficient between antioxidant compounds and antioxidant activity were performed as seen in Table 6. Total polyphenols (TP) and vitamin C showed linear correlation with DPPH, ABTS and FRAP, while total flavonoids was not significant. Correlation of TP with DPPH, ABTS and FRAP were R = 0.933, 0.999 and 0.995, respectively. Correlation of vitamin C with DPPH, ABTS and FRAP had the following R values: 0.834, 0.804 and 0.825, respectively. These results showed that TP and vitamin C contributed to the antioxidant activity of the soups. In addition, a good correlation was observed between DPPH vs ABTS, R = 0.989, DPPH vs ABTS, R = 0.996, and ABTS vs FRAP, R = 0.998.

DISCUSSION

Soups are commonly consumed food supplements that contribute to nutrients and antioxidant compounds in human wellness. Hence, the nutrients and antioxidant components of TVS and PVS soups were analyzed for proximal content during storage at – 18 °C (Table 1). The proximal values of TVS soup were significantly ($p<0.05$) higher than PVS soup. The values for moisture, crude fat, crude fibre, crude protein, and ash were 4%, 28%, 30%, 11.57%, and 14.4%

Table 5: Correlation coefficient of total polyphenol, total flavonoids, vitamin C, and antioxidant activity of frozen soups.

	DPPH	FRAP	ABTS	TFC	TPC	VIT **C**
DPPH	1.000					
FRAP	0.996**	1.000				
ABTS	0.989**	0.998**	1.000			
TFC	-0.300	-0.366	-0.417	1.000		
TPC	0.983**	0.995**	0.999**	-0.449	1.000	
VIT C	0.834*	0.825*	0.804*	0.132	0.785*	1.000

*TPC = total phenol content, TFC = total flavonoid content, Vit. C = vitamin C, ABTS = antioxidant capacity measured in ABTS assay, DPPH = antioxidant capacity measured in DPPH assay, FRAP = antioxidant capacity measured in FRAP. ** and * are significant at ($p<0.05$) or ($p<0.01$)*

higher than those of PVS soup. However, fat and protein contents decreased upto 4 and 6% in the TVS soup, and 7.7 and 4% in PVS soup from 0 to 8th days of storage at -18 ^{0}C. This may be caused by the breakdown of proteins and fat as the storage time increased to the 8th day.

Moisture content in both soups increased from 0 to 5th day. This could result from frozen (solid state) to thawing and expansion (liquid state) of the soups up to the 5th day and a possible salt-water binding action and/or moisture vaporization after the 5th day of the soup storage. In comparison, instant amaranth vegetable soup was reported to contain moisture content of 4.89 to 6.06 g/100g (2), and 8.51 to 9.84% in dried vegetable soup (16). The fibre content also increased in both soups (5.8% in TVS and 8% in PVS soups). This increase might be due to texture change during cooking and lixiviation of soluble fibre from the vegetables into the soups. Crude fibre content in TVS soup was higher than 11% reported in a black soup (17) and 1.0 - 10.27 g/100g in instant amaranth vegetable soup (2). These soups were good sources of fibre considering that in developing countries, food consumption pattern involve intake of high energy foods (18) with the risk of low fibre intake. These soups contains rich sources of macro-nutrients for human nutrition and wellness. Proteins are not only important for growth and maintenance of worn-out tissues, they are also involved in some major physiological functions of the body such as enzymes, hormones and antibody activities (19). Carbohydrates and fat are the main supplier of energy to the body and they facilitate other physiological functions.

The minerals and vitamins content showed a decrease during the storage days (Table 2). TVS soup had higher minerals and vitamins than PVS soup, with the exception of Ca. Fe and Zn were about 46% and 34% higher in TVS soup than PVS soup, thus, TVS soup was an important source of these micro-nutrients. The Ca, P and Fe values were higher in these soups than the Ca (4 mg/100g), P (46 mg/100g) and Fe (3 mg/100g) reported in *egusi* + *Telferia occidentalis* soup (4). Also Fe and Zn contents were higher in these soups than the Fe and Zn concentrations in instant amaranth based vegetable soup (2). On the contrary, Ca and P concentrations were lower in PVS soup than the 250 mg/100g and 480 mg/100g recorded in some selected indigenous soups (20). Mg and Zn contents in both soups compared with the RDA's range of 26 to 260 mg/day for Mg and 5.6 to 14.4mg/day for Zn in various human categories (21). It implies that the soups are good sources of Mg and Zn. The soups show high concentrations of vitamin A (14.85 – 24.22 μg/100g) and vitamin E (18.10 – 26.67 μg/100g). These vitamins are antioxidant compounds which can scavenge free radical actions and prevent oxidative damage to the cellular membrane.

The importance of minerals and vitamins in nutrition and health status cannot be over-emphasized. According to Adebanjo *et al*. (22), calcium and magnesium play significant role in bone mass and teeth development, especially in children, while magnesium aids enzymes, nerve and heart functions. Iron is a key component of haemoglobin and is involved in respiration, immune function and cognitive development of children, while zinc is involved in metabolic processes, sexual development and immune

function (22). Taken together, iron and zinc work in synergy with vitamin A in haemopoisis and prevention of morbidity and mortality in children as a result of raised immune function (23). Due to the high minerals concentrations in the soups, it can be recommended for consumption by children, adolescent, pregnant and lactating mothers for their pivotal roles in boosting physiological health and general wellness.

Antioxidant compounds have the ability to counteract the harmful effect of oxidative damage which results in the development of chronic diseases such as cancers and cardiovascular diseases (24). *Oha* PVS soup contained greater concentrations of antioxidant compounds than *ugu* TVS soup (Table 3) with losses during storage. Antioxidant compounds are also associated with color and sensory acceptability of foods (25). Our finding agrees with the loss of total polyphenols in twenty two fresh cooked vegetables (26), due to lixiviation of the hydrophilic antioxidant compounds into the cooking medium. Vegetables are generally reported to contain several antioxidant compounds that act against oxidative damage in human cells (27) when consumed.

DPPH, FRAP and ABTS+ assays are the common *in vitro* methods used to evaluate and estimate the complex composition of antioxidant compounds in food extracts (28). Both DPPH and ABTS+ assays have been used to screen antioxidant activity and detect antioxidant compounds at low concentrations (29, 30). The results showed that the %DPPH and ABTS of the soups have strong scavenging ability. In comparison, antioxidant activity of twenty two fresh vegetables measured by TRAP, HORAC (26) and crude wild and cooked plant leaves used for food in Italy measured by ABTS-TEAC assays (31) were lower than the values in this study. Katerere *et al*. (32) also reported a lower FRAP value of 2.68 mgGAE/g in some African medicinal and dietary leafy vegetables.Whereas their study was based on TRAP, HORAC and ABTS-TEAC assays, ours was measured by DPPH, ABTS and FRAP assays. The strong antioxidant activity of the soups may have been contributed by hydrophilic and lipophilic antioxidants like carotenoids and tocopherol in the soups. As was affirmed in our study, other authors have shown that polyphenols was responsible for a linear correlation with antioxidant activity of some vegetables (26, 33).

These soups can be used as a functional food and important dietary sources of natural antioxidants for prevention of chronic degenerative diseases caused by tissue oxidation metabolites. For population involved in preservation of soups by frozen storage, this study can form the baseline for comparing nutritive and antioxidant potentials of such soups, and also informed a limited loss of nutrients and antioxidant compounds provided the soup per serving is the quantity that is reheated. TVS soup, however, showed dense nutrient values than PVS soup, whereas, PVS soup had greater concentrations of antioxidant compounds and stronger antioxidant activity than TVS soup.

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Conflict of Interest statement

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