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# EFFECTS OF PROCESSING TREATMENTS ON THE NUTRITIVE COMPOSITION AND CONSUMER ACCEPTANCE OF SOME NIGERIAN EDIBLE LEAFY VEGETABLES.

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**ABSTRACT**

Leafy vegetables are highly perishable food items and require special processing treatments to prevent post harvest losses. Leafy vegetables to be preserved by canning, freezing or dehydration are normally blanched in order to obtain good quality products. In Nigeria, leafy vegetables are preserved by sun-drying and used like freshly harvested vegetables in soups. The effects of these treatments on the nutritive composition and sensory qualities of some edible Nigeria leafy vegetables are reported. Samples (1kg each) of amaranths (*Amaranthus hybridus)*, fluted pumpkin (*Talfaria accidentalis*), gnectum vegetable (*Gnectum africana*), vine spinach (*Basella alba*), bush okro (*Corchorus olitorus*), slippery vine (*Asystacia gangetica*) and cocoyam leaves (*Colocasia esculenta)* were washed, cut into thin slices and sun-dried for 5 hrs daily for 2 days. Samples (1kg) of tomatoes (*Lycopersicon esculentum)* were similarly dried for 4 days. The fresh vegetables (1kg each) were blanched in hot water at $100^{o}C$ for 5-6 min and rapidly cooled to $2^{0}C$ in a freezer. Samples (250g each) of fresh (raw), sun-dried or blanched vegetables were cooked separately for 5min in soups. Sun-drying at $30 \pm 1^{0}C$ and RH 80 – 85% for 10hr resulted in a mean moisture loss of 35.6% with insignificant ($P>0.05$) increases of protein, lipid, crude fiber and total ash. Gnectum vegetable, vine spinach, bush okoro, cocoyam leaves and slippery vine had protein contents ranging from 3.0-5.0. K, Fe, Na, Mg and Ca were the predominant mineral elements analysed while contents of Zn and P were low. Blanching and cooking caused significant ($P \leq 0.05$) reductions in the K, Na, Ca, Mg, Zn, Fe, and P contents of the vegetables. The implications of these results on the nutritive value of these vegetables are discussed. Among the treatments, cooking accounted for 64.3 – 67.5% loss of vitamin C while blanching and sun-drying accounted for 44.8-47.1% and 36.8 – 39.6% respectively. Panelists rated the soups significantly ($P\leq 0.05$) higher for colour, taste, texture, flavour/aroma and overall acceptability characteristics. Fresh fluted pumpkin soup was rated significantly ($P\leq 0.05$) higher for colour, taste, texture and flavour/aroma characteristics, while fresh gnectum vegetable soup was highly rated for taste, flavour/aroma and overall acceptability characteristics. Compared with other dried vegetable soups, dried gnectum vegetable soup had the highest score for colour and taste while dried fluted pumpkin soup had the highest score for flavour/aroma and overall acceptability characteristics. Generally, panelists preferred the fresh to dried vegetable soups.

**Key words**: Blanching, Sun-drying, Cooked, Vitamin C, Sensory attributes.

**ABSTRAIT**

Des légumes verts à feuilles sont des denrées tres périssable donc, ils demandent des traitements spéciaux pour éviter des pertes aprés moissure. Des legumes verts à feuilles à conservation: en boîte, congélation ou déshydration sont normalement blanchis pour avoir des produits de bonne qualities. Au Nigéria des légumes verts à feuilles sont conservés par le séchage solaire et utilisés pour la préparation des potages comme des légumes frais. L'effet des traitements sur les qualités de la composition nutritionelle et sensorielle de certains légumes verts à feuilles comestibles sont prresentés: Les échantillons (1 kilo chacun) de amaranths (*Amaranthus hybridus*), La citrouille (annelée) (*Telfaria occidentalis*), Légume gnectum (*Gnectum africana*), épinard (*Basella alba*), feuille de vigne (*Asystacia gangetica*) et des feuilles de taro (*Colocasia esculenta*) sont lavés, coupés en petits tranches et séchés sous le soleil 5h par jour pour deux jours. Echantillon (1 kilo) de tomates (*Lycopersicon esculentum*) sont égalements séchés pendant quatre jours. Ces légumes (1 kilo chacun étaient blanchis dans l'eau chaude à 100°C pour 5 à 6 minutes et rapidement surgélés à 2°C dans un congélateur. Les échantillons (250g chacun) de légumes frais (crus) séchés dans le soleil ou blanchis étaient preparés séparément pour 5 minutes dans les potages. Séchant en soleil à 30 + 1°C et RH80 – 85% pour 10hs on a noté une perte moyenne en moisissure de 35. 6% avec une augmentation insignifiante ($P>0.05$) en protéine lipide, fibre cru et cendre total. *G. africana*, *B. alba*, *Corchorus* o*litolus*, *Asystacia gangetica*, *C. esculanta* out des protéines qui varies entre 3.0 à 5.0. K, Fe, Na, Mg et Ca étaient les éléments miniraux prédominants analisés; alors que la composition en Zn et P étailent basses. Le blanchiment et le séchage out causé une réduction significative ($P\leq0.05$) en K, Na, Ca, Mg, Zn, Fe et P dans la composition des légumes traités. Les implications de Ces résultats sur la valeur nutritionelle des légumes sont objets de discussions. Parmi les traitements, la preparation contribue en une perte de 64.3 à 67.5% en vitamines C alors que le blanchiment et le séchage en soleil contribuent une perte de 44.8 à 47.1% et 36.8 à 39.6% respectivement. Les juris out fortement estimé les potages pour la couleur, goût, contexture saveur/arôme et l'acceptabilité dans l'ensemble. Le potage préparé avec la citrouille cannelée (*Telfaria occidentalis*) frais a été plus considéré ($P\leq0.05$) en couleur, goût, saveur/arôme et. L'acceptabilité dans l'ensemble que les autres potages préparés avec des légumes séchés, le potage préparé avec du *Gnectum africana* seché a été estimé le meilleur pour la couleur et le goût alors que le potage préparé avec (*Telfaria occidentalis*) séché a été estimé le meilleur en saveur/arôome et l'acceptabilité dans l'ensemble. En général les juris out préférés les potages aux légumes frais aux potages aux légumes séchés.

Les mots clés: Blanchiment, séchage au soleil, Préparé ou cuisinié Vitamin C, sensoriel, Attribut.

## INTRODUCTION

Leafy vegetables are important items of diet in many Nigerian homes. Apart from the variety which they add to the menu. They are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, mineral, vitamins, fiber and other nutrients which are usually in short supply in daily diets [1]. Besides, they add flavour, variety, taste, colour and aesthetic appeal to what would otherwise be a monotonous diet. They are in abundance shortly after the rainy season but become scarce during the dry season during which cultivated types are used. Some eventually find their way to urban markets.

In Nigeria leafy vegetables are rarely processed, presumably due to the general lack of basic preservation facilities for freezing, canning or dehydration. A relatively small quantity of harvested leafy vegetables are however, sun-dried resulting in poor quality products with variable moisture contents and microbial loads thus affecting storage stability. Freezing is generally regarded as the best method of preservation from quality stand-point and for long term preservation of foods. For perishable commodities with very high moisture contents, dehydration results in substantial reduction in weight and bulk with consequent savings in storage and distribution costs. Echetama *et al* [2] reported that Okra dehydrated in a see- saw solar dryer with appropriate pre-drying treatments compared favourably in quality with frozen okra.

Unit operations that intentionally separate the component of foods alter the nutritional and sensory qualities of each fraction compared with the raw material. Blanching which is an important pre-processing heat –treatment of vegetable destined for freezing, canning or dehydration inevitably causes separation and losses [3] of water soluble nutrients (minerals, water soluble vitamins and sugars).

According to fellows [3] blanching at $88^0$C stop all life process, inactivates enzymes, fixes green colour and removes certain harsh flavours common in vegetables. Cooking also cause significant changes in the nutritional properties of foods as well as gelatinisation of starches and coagulation of proteins to improve their digestibility and sensory properties [3]. To the consumer, the most important attributes of a food are its sensory characteristics. These determine an individuals preference for specific products, and small difference between brands of similar products can have a substantial influence on acceptability. Vegetables play crucial roles in alleviating hunger and food security by contributing bulk of the nutritional components in the diets of people where animal products are scarce.

They present unique problems which negatively confront attempts to extend their post harvest useful life span on account of their fragile texture and high moisture contents both of which are responsible for their rapid deterioration, drying difficulties with loss of heat sensitive nutrients. The outstanding preservative method practiced in many homes in Nigeria is sun-drying. This along with blanching and cooking of vegetables in soup preparation have considerable effects on the nutritive value and sensory acceptability of final products. The objective of this investigation was to evaluate the effect of these processing treatments on the nutritive and sensory properties of edible Nigerian vegetables.

## MATERIALS AND METHODS

### Source

Eight types of indigenous leafy vegetables that are widely used in soup preparation were procured from farmers on June 2004. The vegetables were harvested fresh from farms at Aka, Afaha Offot, Mbak, Ikpa, Ikot oku Nsit, Afaha ube, in Uyo urban area. Samples were young and tender at harvest and each species were packed loosely in two-ply polythene (HDPE) bags to minimise heat build-up. Tomatoes (*Lycopersicon esculentum*) were collected in plastic buckets. Samples were separated for identification and only sound samples (leaves and stalk) were used for analysis and soup preparation, samples used are listed in Table 1 with their local and common/scientific names.

### Sample Preparation

One kilogramme each of leafy vegetables were washed and cut into thin slices and spread on medium density (0.926 – 0.940 g/cc) polythene bags on a concrete floor. Samples were sun-dried for 5hrs daily for two days at 30-32$^0$C and RH, 80-85%. Similarly tomato (*Lycopersicon esculentum*) slices were dried for four days. In another experiment one kilogramme each of the vegetables were blanched following the methods described by Ajayi and Onayemi [4]. Briefly, Ikg each of the vegetables were blanched in hot water at 100$^0$C for 5-6mins and rapidly cooled to 2$^0$C in a freezer. The minimum blanching time which is a function of enzyme inactivation was determined by testing for peroxides activity after introducing the vegetables into hot water at 100$^0$C for periods of time up to six minute [5].

### Soup Preparation

Two hundred and fifty grammes each of sliced, fresh and sun-dried gnetum vegetable *(Gnectum africana*) were separately pounded in a mortar. Similarly, 250g each of fresh and dried fluted pumpkin (*Telfaria occidentalis*), amaranths (*Amaranthus hybridus*) and cocoyam leaves (*Colocasia esculenta*) were sliced and dried. Two hundred and fifty and grammes of fresh vine spinach,(*Basella alba)*, which is traditionally used in vegetable soups, were similarly treated and used as control. Both fresh and dried vegetable soups were prepared using standard ingredients (Table 2) as described by Eboh [6]. Briefly, fresh meat cuts were washed and steamed with salt, onions and crushed maggi (spice) for 30 mins, Deboned dried fish was added and cooked in the meat broth for 5 mins, then water was added and cooking sustained for 15 mins before ground crayfish was added. The soup was stirred about 2-3 times then cut vegetables were added and cooked for further 5 mins before oil was added and cooking sustained for further 5 mins.

### Chemical Analysis

Ground samples of raw, sun-dried, blanched and cooked vegetables were analysed for their proximate contents using the AOAC (7) method. The moisture content was determined by air-oven drying at 130$^o$C for 1 hr, and the crude protein contents by microKjeldah method (% protein = N x 6.25). The lipid content was determined using petroleum ether (bp. 60-80$^{o}$C) in a soxhlet extraction apparatus and crude fiber content by dilute acid and alkali hydrolysis. Carbohydrate contents was calculated by difference of total contents from 100. Five (5) grammes of dried powdered sample was dissolved in 6 M HCl solution and the resulting solution was made up to a definite volume (20ml) and used for the determination of minerals. Phosphorus was determined by the phosphomolybdate method of Yuen and Polland (8). Sodium and potassium were determined by flame photometer (Jenway, PF 7, Essex UK) while calcium, magnesium, iron and zinc were determined by Atomic absorption spectrophotometer (Unicam Analytical system, Model 919, Cambridge, UK. Vitamin C was determined by taking a 5g sample, grinding it in a mortar using 100ml of 10% trichloroacetic acid. The ascorbic acid was assayed by visual titration with 2,6 dichlorophenol solution.

**Sensory Evaluation**

A twenty member sensory panel consisting of 12 male and 8 female students who are regular consumers of vegetable soups and familiar with the attributes, investigated the sensory qualities of the prepared soups. Panelists evaluated the soup attributes against a control soup prepared with a popular vegetable (*Basella alba*). Panelists were comfortably seated in booths and served with separate plates of soup and garri (a common starchy staple). The soup samples were coded with four digit letters, spoons, fork and water were provided. Panelists evaluated soup samples for colour, taste, flavour/aroma, texture and overall acceptability characteristics on a 9 = point descriptive scale with 9 = excellent, 7 = very good, 5 = good 3 = fair and 1 = bad as proposed by Larmond (9).

**Statistical Analysis**

**Experimental Design**: A split- plot arrangement fitted with a complete randomization design with species = Whole unit and Treatments (preparations) = subunits was used for the analysis of proximate composition and mineral contents of samples . A randomized complete block design was used for the evaluation of sensory data. Data for all determinations were subjected to analysis of variance (ANOVA) as outlined by Wahua [10]. Fisher's least significant difference (LSD) test was used to identify significant differences among treatment means ($P \leq 0.05$).

**RESULTS**

List of selected indigenous soup vegetables identified in Akwa Ibom State are given in Table 1. The vegetables were identified by their local, English and Scientific names as well as the plant types.

Table 2 presents the recipe for the preparation of vegetable soups. Steaming of fresh meat cuts with salt and other spicies facilitated penetration of spicies into the meat cuts and generation of meat broth. Saltiness of meat broth was reduced after addition of water and fish while the addition of crayfish further improved the taste/flavour properties of the broth. Further thickening of soups resulted from the addition of vegetables while palm oil addition improved flowability of soups during subsequent stirring.

Data in Table 3 show the effects of processing treatments on nutrient contents of the indigenous vegetables. The protein contents of amaranths ranged from 4.0 - 4.6mg/100g while the crude fiber contents ranged from 1.6 -3.4mg/100g.

The moisture contents of the sun-dried sample decreased significantly ($P \leq 0.05$) with corresponding increase in the contents of dry matter. Tomatoes and fluted pumpkin had protein contents ranging from 2.5 – 3.2 and 1.4-2.2mg/100g respectively. Generally, sun-dried and cooked vegetables had significantly ($P \leq 0.05$) lower moisture contents than raw and blanched vegetables. Gnectum vegetable and vine spinach had protein contents ranging from 4.5- 5.2 and 3.7 – 4.2mg/100g respectively while bush okro and slippery vine had protein contents ranging from 1.4 -2.4 and 2.8 – 3.4mg/100g respectively. Sun-drying resulted in a loss of 31.3% moisture but an increase of 0.2% protein and 1.1% crude fiber in cocoyam leaves.

The effects of processing treatments on mineral contents of test vegetables are given in Table 4. Blanching and cooking caused significant ($P \leq 0.05$) reductions in the K, Na,Ca, Zn, Fe and P contents of amaranths, tomatoes, fluted pumpkin gnectum vegetable, spinach, slippery vine and cocoyam leaves, Sun-drying had variable effects on the mineral contents of the experimental vegetables. K, Mg and Ca were the predominant minerals analysed while contents of Zn and P were low. The concentrations of minerals elements vary significantly ($P \leq 0.05$) with treatments, with higher concentrations in the raw and sun-dried samples. Amaranths, tomatoes and fluted pumpkin had the highest contents of Fe, Ca and Na respectively.

Table 5 gives the Vitamin C contents of the treated vegetables. The Vitamin C contents of raw vegetables ranged from 37.5 – 205.4mg/100g. The various treatments (sun-drying, blanching and cooking caused significant ($P \leq 0.05$) losses of Vitamin C. Bush okro had a significantly ($P \leq 0.05$) higher vitamin C content than all the tested samples. Among the treatments, cooking had the most adverse effect accounting for 64.3 – 67.5% losses of vitamin C while blanching and sun-drying accounted for 44.8 - 47.1% and 36.8-39.6% losses respectively. Amaranths, tomatoes and gnectum vegetables had significantly ($P \leq 0.05$) lower contents of vitamin C than other cooked vegetables.

Summary of panel mean scores for the sensory characteristics of soups prepared with fresh and dried vegetables are presented in Table 6. Panelists rated the vegetable soups significantly ($P \leq 0.05$) higher for their colour, taste, texture, flavour/aroma and overall acceptability characteristics. Soups prepared with fresh fluted pumpkin was rated significantly ($P \leq 0.05$) higher than other soups for colour while soups prepared with dried amaranths and dried cocoyam leaves had the least score. Similarly, fresh gnectum vegetable and fresh fluted pumpkin vegetable soups were rated significantly ($P \leq 0.05$) higher than other soups for taste and texture attributes. Fresh gnectum vegetable soups and soups prepared with fresh cocoyam yam leaves had the highest scores for flavour/aroma while dried amaranths soup was down-graded for these attribute. Dried amaranths soup also had the least score for all the tested attributes while fresh gnectum vegetable soups had the highest score for taste, texture, flavour/aroma and overall acceptability characteristics. Considering panel rating of the soups; fresh gnectum vegetable soups scored 85.0% while fresh fluted pumpkin soup had 73.6% of the total attribute scores. Fresh amaranths and fresh cocoyam leaves soup scored 79.1% and 85.3% respectively of the total scores for the attributes. Preference for the vegetable soups was in the order of fresh gnectum vegetable → fresh fluted pumpkin → fresh cocoyam leaves →fresh amaranths soups while preference for dried vegetable soups was in the order of dried fluted pumpkin → dried gnectum vegetable → dried cocoyam leaves →dried amaranths soup.

**DISCUSSION**

The local, English and scientific names of some indigenous vegetables of Akwa-Ibom State are presented in Table 1. Based on their classification into plant types the vegetables were characterised mostly as herbs with some climbers, then a shrub and tree species, *Lyimo et al* [11] also observed that over 90% of the indigenous vegetables of Tanzania were herbs while a few shrubs and trees were characterized. Indigenous or wild vegetables are basically plants whose leaves, fruit or roots are acceptable and used in the diet of rural and urban people as a function of custom, habitat and tradition [12]. Nutritionally they contribute substantially to protein, crude fiber, mineral and vitamin intakes as evident in the following results. Steaming of fresh meat or fish with salt and other spices (Table 2) is a common practice in traditional methods of soup preparation in southern Nigeria [13, 14]. Although the ingredients used in the fish pepper soup [14] and bean soup [13] were similar with those used in our vegetable soups, the concentrations of the ingredients were differed. For instance, up to 14g and 16g of red pepper were used in bean and fresh fish pepper soups respectively. Similarly, Onions (17g) and monosodium glutamate (1.5g) were used in bean soup [13]. Similar to our observations of increased thickness, Akanbi [13] observed that addition of drum dried cowpea paste to the soup increased the viscosity of broths.

Generally, the results (Table 3) indicate that the vegetables were good sources of proteins, crude fiber and carbohydrates. Higher protein contents were recorded for gnectum vegetable, amaranths, bush okro, slippery vine and cocoyam leaves. These results are in accord with those in literature [15,16]. *Lyimo et al* [11] similarly reported protein contents ranging from 3.0-5.0% in bush okro, cocoyam leaves, amaranths and slippery vine. Our results also indicated that sun-drying at 30± $1^0$C and RH 80-85% for 10hr resulted in a mean moisture contents of 35.6% with insignificant (P> 0.05) crude fiber and total ash contents of treated vegetables. Similarly, *Mandhyan et al* [17] observed that sun-drying at 34-$39^0$C and RH40-75% for 16hr caused significant reductions (60.5%) in moisture contents of spinach, cabbage, carrots and peas. Accordingly, reductions in moisture contents resulted in corresponding increases in dry matter contents due to concentration of soluble solids with relatively chemically stable products. Ajayi and Onayemi [4] similarly observed that blanching had variable effects on dry matter composition with insignificant

(P>0.05) reductions in lipid, crude fiber, toal ash and carbohydrate contents but had no effect on the protein content of the vegetables. Lisiewka and Kmicik [18] however observed that blanching reduced the dry matter content of broccoli and cauliflower.

Heating is one of the most important methods developed to extend the shelf life of foods and increasing the availability of nutrients to consumers. Thermal processes such as blanching and pasteurisation increase storage life of foodstuffs and minimise food-borne diseases [3] while cooking is aimed primarily at increasing palatability of food. The reduced protein contents of cooked vegetables could be attributed to the severity of thermal process during cooking [19].

Data on mineral analysis (Table 4) indicate that blanching and cooking caused significant (P ≤0.05) reductions in the K, Na, Ca, Zn and P contents of the vegetables. Similarly, *Oladunmoye et al* [20] observed significant (P≤0.05) reductions in K, Na, Ca, P, Fe and vitamin C contents of blanched and cooked tender and matured cassava leaves. Uzoekwe and Ukhun [21] also reported reductions in the Fe, and Zn contents of scent leaf (*Ocimum gratissmum*), gnectum vegetable, bitterleaf (*Veronica amygdalina*), bush okro and green pepper (*Piper gunineense*) that were used in soup preparation. The result for mineral analysis of the vegetables suggest consumption of large quantities to meet the Recommended Daily Allowance (RDA) for minerals. For instance, adult minimum K requirement for health set by the 1989 RDA is 2000mg daily. It would require up to 476.2 mg/100g of cooked *amaranths* to meet the RDA. K is a primary electrolyte and major cation inside the cell and low blood K is a life – threatening problem [22]. Similarly, consumption of large amounts of *amaranths, fluted pumpkin, tomatoes, or gnectum vegetable* would be important to meeting the RDA for Na. A Na intake of less than 2g/day increases calcium loss in urine and high intakes can contribute to hypertension in some people [22] Therefore the low level of Na in *bush okro, slippery vine and cocoyam leaves* make them suitable for use in Na restricted diets. Calcium is probably mainly associated with the pectic substance of the cell wall and could significantly influence texture. Its high content in fruit vegetables such as *tomatoes* was expected. Its low contents in leafy vegetables suggests a low intake by vegetarians that must seek alternative sources to meet their needs for calcium. This is important because the cells need calcium and more than 99% of calcium in the body is used as a structural component of bones and teeth. This represents about 40% of all the minerals present in the body [22]. *Fluted pumpkin* had the highest magnesium content while moderate concentrations were recorded in other leafy vegetables. Magnesium occur abundantly in chloroplasts as a constituent of chlorophyll molecule. Its low concentrations in most of the vegetables could be attributed to age of plants and cultural practices. The levels obtained in this studies is low to meet the Recommended Daily Allowance (RDA) of 400mg/day for men 19-30 years old and 310mg/day for women 19-30 years old [23].

The levels of phosphorus obtained were similarly low. Phosphrus is a constituent of cytoplasm and nuclear protein, phospholipids and nucleic acids, as well as taking important part in carbohydrate metabolism. Efficient absorption plus the wide availability in foods makes phosphorus a much less important mineral than calcium [23] in diet planning. Vegetables are generally poor sources of iron. However, Fe,

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contents of *amaranths, fluted pumpkin* and *gnectum vegetable* can be considered adequate when viewed against an RDA of 8mg Fe/day for men (19 years and older) and for women over 50 years, 18mg/day for girls and women 11 to 50 years old [24]. However, neither the total iron content nor the nutrient density of the individual food constitute an accurate guide for choosing dietary sources of iron. Rather the bioavailability of iron present in a meal, which depends on its form and the presence or absence of factors that influence absorption and the body's need for iron ultimately determine how much iron that is actually delivered to the body. Zinc was one of the lowest mineral content of the vegetables when considered against an average requirement of 9.4mg/day for men and 6.8 mg/day for women [24]. Zinc deficiency in developing countries is becoming a growing concern because it has been shown that zinc deficiency is related not only to decreased growth but also increased morbidity. Studies [25] have shown zinc supplementation to be effective in reducing the morbidity associated with infections in infants and children, possibly improving immune function.

Table 5 gives the Vitamin C contents of the treated vegetables. Vitamin C contents (mg/100g) up to 20.0, 21.3, 25.3, 59.7, 42.3, and 38.7 have been reported in cabbage, lettuce, endives, spinach, spinach beet, and spinach beet leaves respectively [26]. Values obtained in this study support the reports in literature [27- 30]. Addo [31] observed significantly low level losses (21.3-36.5%) of ascorbic acid in sun-dried than in cooked vegetables. He observed that losses varied with vegetable cultivars, for instance, fresh pepper lost up to 45% of its vitamin C content while baobab leaves retained up to 65% of its vitamin C contents. Blanching prior to freezing or drying to inactive enzymes which could contribute to undesirable changes in colour, flavour or nutritive value during storage also cause significant loss of vitamin C. However, vegetables from the *Lycopersicon* family as represented by tomatoes with thick pulp had longer blanching times in comparison to the smaller, thin – leaf vegetables from *Amaranthaceae* family. This observation indicate that the thickness and size of vegetable pieces determine, in part, the effectiveness of blanching treatment. For this reason, most commercial vegetable plant chop their vegetables into smaller sizes prior to blanching.

The reported losses of ascorbic acid during blanching or cooking are enormous and may vary between 40 and 70% in some cooked vegetables when processed at 100°C for 15 min [32] other researchers observed losses up to 66%. 63%to 73% and 62 to 93% ascorbic acid in cooked vegetables [29, 30]. These values support the results obtained for this studies.

The high solubility of ascorbic acid in water and the relative ease with which it is oxidized makes this vitamin particularly susceptible to processing conditions. The route and rate of oxidation of ascorbic acid is influenced by several factors including pH, trace metals, enzymes, presence of oxygen as well as time and temperature. Precooking preparation of vegetables followed in this work exposed the tissue. Under this conditions, ascorbic acid oxidase may react with molecular oxygen and cause direct destruction of the vitamins. The traditional Nigerian soups are water-in-oil emulsions, and consequently, the large quantities of water used often predispose ascorbic acid to loss by leaching. Atmospheric oxidation of ascorbic acid also occurs during cooking of soups. Also this reaction is catalysed by natural copper, iron and anthocyanin which occur in the vegetables [33]. Beside the numerous organic acid contents of vegetables, there are also furan types compounds and lactones. These acids may account for the low pH values (1.6-2.5) of cooked vegetable soups. Generally, panelists preferred the fresh vegetable soups to the dried vegetable soups. Ajayi and Onayemi [4] have reported that sun-dried vegetables are generally of poor quality especially as their colour and taste are compromised.

**CONCLUSION**

Sun drying at 30 ± $1^0$C and RH 80 -85% for 10hrs resulted in a mean moisture loss of 35.6% with insignificant (P >0.05) reductions in proteins, lipid, crude fiber and total ash contents of treated vegetables. Blanching had variable effects on the dry matter contents of treated vegetables. Sun–dried and cooked vegetables had higher dry matter contents than raw and blanched vegetables. Blanching and cooking caused significant (P ≤ 0.05) reductions in the K, Na, Ca, Zn, Fe and P contents of amaranths, tomatoes, fluted pumpkin, gnectum vegetable, vine spinach, slippery vine and cocoyam leaves. The mineral contents of the samples vary with processing treatments with significantly (P ≤ 0.05) higher concentrations in raw and sun–dried vegetables.
Cooking had the most adverse effect on vitamin C, accounting for 64.3 – 67.5% loss while blanching and sun-drying accounted for 44.8-47.1% and 36.8 – 39.6% losses respectively. Generally, panelists preferred the fresh vegetable to dried vegetable soups.

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**Table 1: Selected indigenous soup-vegetables identified in Akwa Ibom State**

| Local name | Common name | Scientific name | Family name | Plant type |
|---|---|---|---|---|
| Tete | Amaranthus | *Amaranthus* | *Anarantheceae* | Herb |
| Totomato | Tomato | *Lycopersicon esculentum* | *Solaneceae* | Shrub |
| Nyae | Fluted pumpkin | *Talfaria occidentalis* | *Cucurbitaceae* | Climber |
| Sogo | Gnectum vegetable | *Gnectum africana* | *Gnectraceae* | Climber |
| Atameme | Spinach | *Basella alba* | *Basellaceae* | Herb |
| Afia adot | Bush okro | *Corchrus olictorus* | *Tiliaceae* | Tree |
| | Slippery vine | *Asystacia gangectice* | *Anthraceae* | Herb |
| Geere | Cocyam leaves | *Colocasia esculents* | *Araceae* | herb |

**Table 2: Recipe for vegetable soups**.

| Ingredients | Amounts |
|---|---|
| Dried Fish (kg) | 1.0 |
| Meat (kg) | 1.0 |
| Ground Crayfish (g) | 90.0 |
| Onions (g) | 25 |
| Maggi (g) | 15 |
| Pepper (g) | 15 |
| Salt (g) | 10 |
| Palm Oil (g) | 35 |
| Vegetables (g) | 250 |
| Water (ml) | 1000 |

Adapted from Eboh, 2000



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**Table 3: Effect of processing treatments on proximate composition of selected indigenous vegetables**

| Treatment | Moisture (%) | Crude Protein (%) | Lipid (%) | Crude Fiber (%) | Total Ash (%) | Carbohydrate (by difference) |
|---|---|---|---|---|---|---|
| | | ***Amaranthus hybridus*** | | | | |
| Raw | $88.5^c$ | $4.3^a$ | $0.8^a$ | $1.6^a$ | $2.2^a$ | $2.6^a$ |
| Blanched | $87.6^c$ | $4.1^a$ | $0.7^a$ | $2.0^a$ | $2.6^a$ | $3.0^a$ |
| Sun-dried | $59.3^a$ | $4.6^a$ | $1.2^a$ | $3.4^a$ | $4.1^a$ | $27.4^b$ |
| Cooked | $65.2^b$ | $4.0^a$ | $0.3^a$ | $2.2^a$ | $2.7^a$ | $25.6^b$ |
| **LSD = 6.5** | | | | | | |
| | | ***Lycopersicon esculentum*** | | | | |
| Raw | $89.2^c$ | $2.8^a$ | $1.3^a$ | $1.4^a$ | $1.8^a$ | $3.5^a$ |
| Blanched | $88.4^c$ | $2.5^a$ | $1.1^a$ | $1.8^a$ | $2.4^a$ | $3.8^a$ |
| Sun-dried | $56.4^a$ | $3.2^a$ | $1.6^a$ | $2.6^a$ | $3.0^a$ | $33.2^b$ |
| Cooked | $63.8^b$ | $2.4^a$ | $1.0^a$ | $2.1^a$ | $2.5^a$ | $28.2^b$ |
| **LSD = 7.2** | | | | | | |
| | | **Telfaria occidentalis** | | | | |
| Raw | $91.9^c$ | $1.8^a$ | $0.8^a$ | $1.4^a$ | $2.0^a$ | $2.1^a$ |
| Blanched | $90.8^c$ | $1.6^a$ | $0.7^a$ | $1.7^a$ | $2.3^a$ | $2.9^a$ |
| Sun-dried | $58.7^a$ | $2.2^a$ | $1.4^a$ | $2.6^a$ | $3.1^a$ | $32.0^b$ |
| Cooked | $66.2^b$ | $1.4^a$ | $0.5^a$ | $2.3^a$ | $2.8^a$ | $26.8^b$ |
| **LSD = 7.2** | | | | | | |
| | | ***Gnectum Africana*** | | | | |
| Raw | $86.4^c$ | $5.2^a$ | $0.7^a$ | $1.8^a$ | $2.3^a$ | $3.6^a$ |
| Blanched | $86.2^c$ | $5.0^a$ | $0.6^a$ | $2.2^a$ | $2.8^a$ | $3.2^a$ |
| Sun-dried | $54.7^a$ | $5.6^a$ | $1.2^a$ | $2.7^a$ | $3.2^a$ | $32.6^b$ |
| Cooked | $61.5^b$ | $4.5^a$ | $0.5^a$ | $2.5^a$ | $3.0^a$ | $28.0^b$ |
| **LSD = 7.2** | | | | | | |
| | | ***Basella alba*** | | | | |
| Raw | $86.2^c$ | $3.8^a$ | $0.7^a$ | $1.3^a$ | $1.7^a$ | $6.3^a$ |
| Blanched | $85.5^c$ | $3.6^a$ | $0.6^a$ | $1.9^a$ | $2.4^a$ | $6.0^a$ |
| Sun-dried | $54.8^a$ | $4.2^a$ | $0.9^a$ | $2.7^a$ | $3.1^a$ | $34.3^b$ |
| Cooked | $61.8^b$ | $3.7^a$ | $0.6^a$ | $1.6^a$ | $2.2^a$ | $30.1^b$ |
| **LSD = 7.0** | | | | | | |
| | | ***Corchorus olitorus*** | | | | |
| Raw | $88.7^c$ | $2.0^a$ | $0.7^a$ | $1.6^a$ | $2.3^a$ | $4.7^a$ |
| Blanched | $88.1^c$ | $1.6^a$ | $0.4^a$ | $2.4^a$ | $3.2^a$ | $4.3^a$ |
| Sun-dried | $56.6^a$ | $2.4^a$ | $0.8^a$ | $2.7^a$ | $3.4^a$ | $34.1^b$ |
| Cooked | $64.1^b$ | $1.4^a$ | $0.3^a$ | $2.2^a$ | $2.8^a$ | $29.2^b$ |
| **LSD = 7.2** | | | | | | |
| | | ***Asystacia gangetica*** | | | | |
| Raw | $87.2^c$ | $3.2^a$ | $0.5^a$ | $1.5^a$ | $2.4^a$ | $5.2^a$ |
| Blanched | $86.9^c$ | $3.0^a$ | $0.4^a$ | $2.1^a$ | $2.6^a$ | $5.0^a$ |
| Sun-dried | $57.3^a$ | $3.4^a$ | $0.6^a$ | $2.5^a$ | $3.3^a$ | $32.9^b$ |
| Cooked | $64.3^b$ | $2.8^a$ | $0.4^a$ | $2.3^a$ | $3.0^a$ | $27.2^b$ |
| LSD = 6.7 | | | | | | |
| | | ***Colocasia esculenta*** | | | | |
| Raw | $88.1^c$ | $3.1^a$ | $0.5^a$ | $1.3^a$ | $2.0^a$ | $5.0^a$ |
| Blanched | $87.5^c$ | $3.0^a$ | $0.5^a$ | $1.8^a$ | $2.5^a$ | $4.7^a$ |
| Sun-dried | $56.8^a$ | $3.3^a$ | $0.9^a$ | $2.4^a$ | $2.8^a$ | $33.8^b$ |
| Cooked | $64.4^b$ | $2.9^a$ | $0.4^a$ | $2.1^a$ | $2.6^a$ | $27.6^b$ |
| **LSD = 7.0** | | | | | | |

abc Means in the same columns not followed by the same superscripts are significantly different ($P \leq 0.05$)

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**Table 4: Effect of processing treatments on mineral contents of selected indigenous soup-vegetable of Akwa Ibom State.**

| | Components mg/100g | | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatments** | **K** | **Na** | **Ca** | **Mg** | **Zn** | **Fe** | **P** |
| **Amaranthus hybridus** | | | | | | | |
| Raw | 4.5$^{b}$± 0.1 | 3.6$^{c}$± 0.1 | 0.2$^{b}$± 0.1 | 0.4$^{b}$± 0.1 | 0.8$^{c}$± 0.1 | 11.8$^{c}$± 0.3 | 0.6$^{c}$± 0.1 |
| Blanched | 4.2$^{a}$± 0.1 | 3.2$^{b}$± 0.2 | 0.1$^{a}$± 0.2 | 0.3$^{a}$± 0.2 | 0.7$^{b}$± 0.3 | 11.4$^{b}$± 0.2 | 0.5$^{b}$± 0.1 |
| Sun-dried | 4.5$^{b}$± 0.3 | 3.6$^{c}$± 0.2 | 0.3$^{c}$± 0.1 | 0.4$^{b}$± 0.1 | 0.9$^{d}$± 0.2 | 12.1$^{d}$± 0.1 | 0.5$^{b}$± 0.2 |
| Cooked | 4.2$^{a}$± 0.1 | 3.0$^{a}$± 0.3 | 0.1$^{a}$± 1.2 | 0.3$^{a}$± 0.1 | 0.6$^{a}$± 0.1 | 11.2$^{a}$± 0.2 | 0.4$^{a}$± 0.3 |
| LSD = 0.1 | | | | | | | |
| **Lycopersicon esculentum** | | | | | | | |
| Raw | 5.8$^{c}$ ± 0.3 | 2.5$^{b}$ ± 0.1 | 8.5$^{b}$ ± 0.3 | 0.4$^{b}$ ± 0.1 | 0.5$^{c}$ ± 0.1 | 0.8$^{c}$ ± 0.2 | 0.6$^{b}$ ± 0.2 |
| Blanched | 5.4$^{b}$ ± 0.2 | 2.0$^{a}$ ± 0.3 | 8.1$^{a}$ ± 0.3 | 0.3$^{a}$ ± 0.2 | 0.4$^{b}$ ± 0.1 | 0.6$^{a}$ ± 0.1 | 0.5$^{a}$ ± 0.1 |
| Sun-dried | 5.9$^{d}$ ± 0.1 | 2.5$^{b}$ ± 0.3 | 8.6$^{c}$ ± 0.1 | 0.4$^{b}$ ± 0.2 | 0.5$^{c}$ ± 0.2 | 0.8$^{c}$ ± 0.1 | 0.7$^{c}$ ± 0.2 |
| Cooked | 5.2$^{a}$ ± 0.3 | 2.0$^{a}$ ± 0.2 | 8.1$^{a}$ ± 0.2 | 0.3$^{a}$ ± 0.3 | 0.3$^{a}$ ± 0.1 | 0.7$^{b}$ ± 0.1 | 0.5$^{a}$ ± 0.1 |
| LSD = 0.1 | | | | | | | |
| **Telfaria occidentalis** | | | | | | | |
| Raw | 2.8$^{c}$ ± 0.3 | 3.5$^{b}$ ± 0.1 | 0.5$^{b}$ ± 0.1 | 3.6$^{b}$ ± 0.2 | 1.3$^{b}$ ± 0.5 | 8.0$^{b}$ ± 0.3 | 0.4$^{c}$ ± 0.1 |
| Blanched | 2.6$^{b}$ ± 0.2 | 3.4$^{a}$ ± 0.2 | 0.4$^{a}$ ± 0.1 | 3.5$^{a}$ ± 0.1 | 1.3$^{b}$ ± 0.3 | 7.8$^{a}$ ± 0.2 | 0.3$^{b}$ ± 0.1 |
| Sun-dried | 3.0$^{d}$ ± 0.3 | 3.6$^{c}$ ± 0.1 | 0.5$^{b}$ ± 0.2 | 3.6$^{b}$ ± 0.2 | 1.3$^{b}$ ± 0.2 | 8.1$^{c}$ ± 0.1 | 0.4$^{c}$ ± 0.1 |
| Cooked | 2.5$^{a}$ ± 0.2 | 3.4$^{a}$ ± 0.1 | 0.3$^{a}$ ± 0.1 | 3.5$^{a}$ ± 0.1 | 1.2$^{a}$ ± 0.2 | 7.8$^{a}$ ± 0.2 | 0.2$^{a}$ ± 0.1 |
| **LSD = 0.1** | | | | | | | |
| **Gnectum Africana** | | | | | | | |
| Raw | 1.6$^{b}$ ± 0.2 | 2.0$^{d}$ ± 0.3 | 0.2$^{a}$ ± 0.3 | 0.4$^{b}$ ± 0.2 | 0.8$^{b}$ ± 0.2 | 5.8$^{c}$ ± 0.2 | 0.3$^{b}$ ± 0.1 |
| Blanched | 1.5$^{a}$ ± 0.1 | 1.8$^{b}$ ± 0.2 | 0.2$^{a}$ ± 0.2 | 0.2$^{a}$ ± 0.1 | 0.7$^{a}$ ± 0.3 | 5.6$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 |
| Sun-dried | 1.6$^{b}$ ± 0.1 | 1.9$^{c}$ ± 0.1 | 0.2$^{a}$ ± 0.2 | 0.3$^{b}$ ± 0.2 | 0.8$^{b}$ ± 0.1 | 5.7$^{b}$ ± 0.2 | 0.3$^{b}$ ± 0.1 |
| Cooked | 1.5$^{a}$ ± 0.2 | 0.8$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.7$^{a}$ ± 0.3 | 5.6$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 |
| **LSD = 0.1** | | | | | | | |
| *Basella alba* | | | | | | | |
| Raw | 4.0$^{d}$ ± 0.3 | 0.2$^{b}$ ± 0.3 | 1.0$^{d}$ ± 0.4 | 0.6$^{b}$ ± 0.2 | 0.2$^{b}$ ± 0.2 | 0.6$^{b}$ ± 0.3 | 0.6$^{b}$ ± 0.2 |
| Blanched | 3.6$^{b}$ ± 0.1 | 0.1$^{a}$ ± 0.2 | 0.7$^{b}$ ± 0.1 | 0.5$^{a}$ ± 0.1 | 0.2$^{b}$ ± 0.1 | 0.5$^{a}$ ± 0.2 | 0.5$^{a}$ ± 0.1 |
| Sun-dried | 3.8$^{c}$ ± 0.1 | 0.2$^{b}$ ± 0.1 | 0.9$^{c}$ ± 0.2 | 0.6$^{b}$ ± 0.2 | 0.2$^{b}$ ± 0.1 | 0.6$^{b}$ ± 0.1 | 0.6$^{b}$ ± 0.1 |
| Cooked | 3.5$^{a}$ ± 0.1 | 0.1$^{a}$ ± 0.3 | 0.6$^{a}$ ± 0.3 | 0.5$^{a}$ ± 0.1 | 0.1$^{a}$ ± 0.2 | 0.5$^{a}$ ± 0.1 | 0.5$^{a}$ ± 0.3 |
| **LSD = 0.1** | | | | | | | |
| **Corchorus olitorus** | | | | | | | |
| Raw | 1.2$^{c}$ ± 0.2 | 0.4$^{b}$ ± 0.2 | 0.2$^{a}$ ± 0.3 | 0.3$^{b}$ ± 0.1 | 0.4$^{b}$ ± 0.2 | 0.9$^{b}$ ± 0.1 | 0.4$^{b}$ ± 0.2 |
| Blanched | 1.0$^{a}$ ± 0.3 | 0.3$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.3$^{a}$ ± 0.1 | 0.7$^{a}$ ± 0.3 | 0.3$^{a}$ ± 0.1 |
| Sun-dried | 1.1$^{b}$ ± 0.2 | 0.4$^{b}$ ± 0.2 | 0.2$^{a}$ ± 0.2 | 0.2$^{a}$ ± 0.2 | 0.4$^{b}$ ± 0.1 | 0.8$^{b}$ ± 0.2 | 0.4$^{b}$ ± 0.1 |
| Cooked | 1.0$^{a}$ ± 0.1 | 0.3$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 0.3$^{a}$ ± 0.3 | 0.7$^{a}$ ± 0.2 | 0.3$^{a}$ ± 0.1 |
| **LSD = 0.1** | | | | | | | |
| **Asystacia gangetica** | | | | | | | |
| Raw | 4.2$^{d}$ ± 0.1 | 0.3$^{b}$ ± 0.1 | 1.6$^{c}$ ± 0.2 | 0.8$^{c}$ ± 0.1 | 0.3$^{b}$ ± 0.2 | 0.6$^{c}$ ± 0.2 | 0.5$^{b}$ ± 0.2 |
| Blanched | 4.0$^{b}$ ± 0.2 | 0.2$^{a}$ ± 0.3 | 1.4$^{a}$ ± 0.1 | 0.7$^{b}$ ± 0.2 | 0.2$^{a}$ ± 0.1 | 0.5$^{b}$ ± 0.2 | 0.4$^{a}$ ± 0.1 |
| Sun-dried | 4.1$^{b}$ ± 0.3 | 0.3$^{b}$ ± 0.1 | 1.5$^{b}$ ± 0.3 | 0.8$^{c}$ ± 0.2 | 0.3$^{b}$ ± 0.1 | 0.5$^{b}$ ± 0.2 | 0.5$^{b}$ ± 0.2 |
| Cooked | 3.9$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.1 | 1.4$^{a}$ ± 0.2 | 0.6$^{a}$ ± 0.1 | 0.2$^{a}$ ± 0.2 | 0.4$^{a}$ ± 0.1 | 0.4$^{a}$ ± 0.1 |
| **LSD = 0.1** | | | | | | | |
| *Colocasia esculenta* | | | | | | | |
| Raw | 2.4$^{d}$ ± 0.4 | 0.5$^{b}$ ± 0.4 | 0.7$^{c}$ ± 0.1 | 0.7$^{c}$ ± 0.1 | 0.6$^{c}$ ± 0.1 | 0.4$^{b}$ ± 0.4 | 0.7$^{b}$ ± 0.3 |
| Blanched | 2.2$^{b}$ ±0.1 | 0.4$^{a}$ ± 0.2 | 0.5$^{a}$ ± 0.2 | 0.5$^{a}$ ± 0.2 | 0.5$^{b}$ ± 0.2 | 0.3$^{a}$ ± 0.4 | 0.6$^{a}$ ± 0.2 |
| Sun-dried | 2.3$^{c}$ ± 0.2 | 0.5$^{b}$ ± 0.1 | 0.6$^{b}$ ± 0.3 | 0.6$^{b}$ ± 0.3 | 0.5$^{b}$ ± 0.1 | 0.4$^{b}$ ± 0.2 | 0.7$^{b}$ ± 0.1 |
| Cooked | 2.1$^{a}$ ± 0.2 | 0.4$^{a}$ ± 0.2 | 0.5$^{a}$ ± 0.1 | 0.5$^{a}$ ± 0.1 | 0.4$^{a}$ ± 0.1 | 0.3$^{a}$ ± 0.1 | 0.6$^{a}$ ± 0.1 |
| **LSD = 0.1** | | | | | | | |

a,b,c Means in the same columns not followed by the same superscripts are significantly different ($P \leq 0.05$)

**Table 5: Vitamin C* contents of treated vegetables (mg/100g)**

| Samples | Raw | Blanched | Sun-dried | Cooked |
|---|---|---|---|---|
| Amaranths | $58.1^{b}$ | $31.9^{b}$ (45.1) | $36.7^{b}$ (36.8) | $20.5^{a}$ (64.8) |
| Tomatoes | $37.5^{a}$ | $20.4^{a}$ (45.6) | $23.5^{a}$ (37.1) | $13.1^{a}$ (65.1) |
| Fluted pumpkin | $160.2^{e}$ | $85.3^{e}$ (46.8) | $100.6^{d}$ (37.2) | $53.8^{c}$ (66.4) |
| Gnectum vegetable | $56.8^{b}$ | $30.4^{b}$ (46.5) | $36.3^{b}$ (36.1) | $20.3^{a}$ (64.3) |
| Vine Spinach | $98.1^{d}$ | $54.2^{d}$ (44.8) | $59.3^{c}$ (39.6) | $34.8^{b}$ (64.5) |
| Bush okro | $205.4^{g}$ | $108.7^{f}$ (47.1) | $124.9^{f}$ (39.2) | $67.1^{d}$ (67.3) |
| Slippery vine | $178.2^{f}$ | $93.6^{e}$ (47.5) | $110.1^{e}$ (38.2) | $57.9^{c}$ (67.5) |
| Cocoyam leaves | $82.6^{c}$ | $43.9^{c}$ (46.8) | $51.7^{c}$ (37.4) | $27.8^{ab}$ (66.3) |
| **LSD = 9.0** | | | | |

*Values are means of three determinations. Means in the columns not followed by the same superscripts differ significantly (P≤ 0.05).
Data in parentheses are percentage losses of Vitamin C for the respective treatments.

**Table 6: Summary of panel means scores of sensory attributes for soups prepared with fresh and dried vegetables.**

| | Sensory attributes | | | | |
|---|---|---|---|---|---|
| **Soups** | **Colour** | **Taste** | **Texture** | **Flavour/ aroma** | **Overall acceptability** |
| Fresh gnectum vegetable | $8.6^{e}$ | $7.8^{e}$ | $7.2^{d}$ | *$8.0^{e}$ | $8.0^{e}$ |
| Dried gnectum vegetable | $7.2^{c}$ | $6.4^{b}$ | $5.4^{b}$ | $6.2^{c}$ | $5.4^{b}$ |
| Fresh fluted pumpkin | $9.6^{f}$ | $7.8^{e}$ | $7.6^{d}$ | $7.8^{d}$ | $6.2^{c}$ |
| Dried fluted pumpkin | $6.8^{e}$ | $6.2^{a}$ | $6.0^{c}$ | $7.7^{d}$ | $6.4^{c}$ |
| Fresh amaranths | $7.4^{c}$ | $6.8^{c}$ | $7.4^{d}$ | $6.2^{c}$ | $7.8^{e}$ |
| Dried amaranths | $6.2^{a}$ | $5.8^{a}$ | $4.8^{a}$ | $3.5^{a}$ | $4.8^{a}$ |
| Fresh cocoyam leaves | $7.8^{d}$ | $7.4^{d}$ | $7.4^{d}$ | $8.0^{e}$ | $7.8^{e}$ |
| Dried cocoyam leaves | $6.0^{a}$ | $6.2^{b}$ | $6.0^{c}$ | $5.4^{b}$ | $5.6^{b}$ |
| Control * | $7.4^{c}$ | $6.7^{c}$ | $7.3^{d}$ | $6.6^{d}$ | $7.0^{d}$ |
| **LSD = 0.24** | | | | | |

* Control = Vine Spinach.
* Means in the columns not followed by the same superscripts differ significantly (P≤ 0.05).


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