

Full Length Research Paper

The effect of sun and shade drying on chemical composition of *Vitex doniana*, *Ipomoea aquatica* and *Cochorus* and their soups

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This study investigated the effect of sun and shade drying on chemical composition of African black plum “Uchakoro” (*Vitex doniana*) Bush okro leaf “Ewedu” (*Corchorus*) and wild lettuce “yaririn” (*Ipomoea aquatica*) vegetables and their soap meals. These vegetables were bought in bulk from Ibaji Local market in Kogi State, Nigeria. The foods were washed with clean water, plucked from the stalk, sun and shade dried to mimic the traditional food processing techniques. The fresh vegetables served as the controls. A portion of each processed vegetable was pulverized, sieved, packaged in name labeled polythene bags and kept in cool dry place until used for various chemical analysis. The other portions as well as the fresh vegetables were used to prepare various traditional indigenous soup meals using similar consistency traditional recipes for each soup. The chemical composition of both the vegetables and their soups were determined using standard assay methods on dry matter basis. Means, standard deviation and least significant difference (LSD) were adopted to separate and compare means from data generated. The protein, ash, fat and fibre values for both the sun and the shade dried vegetables were higher than those of fresh samples ($P<0.05$). The fresh vegetables had higher calcium, iron and zinc than the sun and the shade dried vegetables. On the other hand, sun and shade drying decreased beta carotene and ascorbate as against those of the fresh samples. The protein, ash, fat and carbohydrate values for soups prepared with dried vegetables were much higher than those of their controls. The soups prepared with dried vegetables had lower iron, calcium, zinc and iodine than those prepared with fresh vegetables ($P<0.05$). The higher, iodine, zinc, beta carotene and ascorbate values for shade dried samples regardless of the types of vegetables indicated that shade drying had an edge over sun drying as traditional food processing technique to preserve nutrients in these vegetables.

Key words: Dry methods, vegetables, nutrient, preservation.

INTRODUCTION

Traditional dishes are amongst the oldest and deeply ingrained aspects of African culture. Historical evidence of African dishes dating back to the Stone Age was discovered in Olorgesailie, Kenya. This is a historical site on the floor of the Great Rift Valley, South of Nairobi. Over 5,000 years ago hunter-gathers, commonly called the ndorobo, occupied much of East Africa. The ndorobo were assimilated by migrants as such lost much of their cultural identity, such as knowledge of their traditional dishes (Katz and Weaver, 2003). Interestingly, Eaton and Konner (1995) investigated dietary shifts over several millennia in Africa. They concluded that the human diet was far superior with the hunting and gathering

subsistence of Paleolithic times as compared with the present-day dishes largely based on processed and manufactured foods. External influences (Western life styles) caused changes in African dishes. This has never been more apparent than the present day Nigeria and Ibaji community in particular. The faster people adopt new food pattern, the less likely traditional dishes knowledge will be passed on to the next generation. The loss of traditional dishes precipitated decrease in culture-specific food activities and decreased dietary diversity.

There is need to investigate the nutrient content of traditional African dishes. This information is necessary for understanding how traditional dishes could potentially

improve the health status of indigenous populations throughout Africa intensive exploration of traditional African dishes could provide insight into the vast and nutrient-rich diversity of foods (dishes) available in various regions of this vast continent. Historical evidenced of the richness of traditional African dishes is currently on nutrient content of the dishes. This new evidence has the potential to trigger more thorough study of traditional African dishes today (Vanden et al., 2000; Wu and Wall, 2000).

It is imperative to collect historical and most current data on some traditional Nigerian dishes, particularly those of my community (Ibaji) in Kogi State of Nigeria that are at the verge of extinction. Raising awareness and inspiring study of traditional dishes may be of significant cultural and health related importance for the indigenous people of Ibaji in Kogi State, Nigeria. The present study tends to evaluate the chemical compositions of three indigenous vegetables and their traditional soup meals. These vegetables were African black plum (*Vitex doniana*), Bush okro leaf "Ewedu" (*Corchorus*) and wild lettuce (*Ipomoea aquatica*). The result of this work might add to information for compiling Nigerian food composition table.

MATERIALS AND METHODS

African black plum (*V. doniana*), wild lettuce (*I. aquatica*) and bush okro leaf "Ewedu" (*Corchorus*) were purchased in bulk from Unale-Ibaji market Kogi State, Nigeria.

Sample preparation

These three vegetables were carefully plucked, washed with clean water, and divided each into three equal portions. The fresh portions served as controls. The other two portions of each vegetable were sun and shade dried for 8 days and 10 days respectively at individual constant level of drying to 98% dry matter using gravimetric method (Figure 1). *V. doniana* "Uchakoro" was the only vegetable blanched to mimic the traditional method to remove its bitter taste that might adversely affect the acceptability of its soup meal. Each dried sample was divided into two portions. One portion of each dried vegetable was pulverized into fine flour after sieving with 70 mesh screen, packaged in name labeled polythene bags and stored in a cool dry place at $25\pm 2^{\circ}\text{C}$ until used for various chemical analysis. The unpulverized samples (whole) were used to prepare traditional soup meals for both chemical analysis and organoleptic evaluation.

Both dried and fresh vegetables were analyzed on dry matter basis for various nutrients and antinutrients using standard method (AOAC, 1995). The soup meals based on these vegetables were prepared using traditional recipe for each soup meal with similar consistency. The soups were also analyzed for their chemical composition prior to their organoleptic evaluation.

Analytical methods

Moisture content of each sample was determined as described by AOAC (1995) methods. Crude protein was determined by the micro-kjeldahl method using 6.25 as the conversion factor. Ash,

crude fibre, fat, tannins and phytate were also determined as described by AOAC (1995). Carbohydrate was obtained by difference. Minerals were determined using atomic absorption spectrophotometer.

Statistical analysis

The data generated were subjected to various statistical analysis such as means, standard deviation. Least significant difference (LSD) was adopted to separate and compare means.

RESULTS

Table 1 presents the effect of processing on proximate composition and caloric value of three green leafy vegetables. The proximate values were based on dry weight. The caused increases in values more than one would expect in vegetables.

The protein content of *V. doniana* ranged from 6.35 to 25.91%. As one would expect the fresh sample that high moisture had higher protein relative to those of sun and shade dried samples (25.91 vs 11.32 and 6.35% ($p < 0.05$)). The sun dried samples had higher protein than the shade dried samples (11.32 vs 6.35%). The difference was significant ($p < 0.05$). The sun dried sample had 4.97% protein more than the shade dried sample (11.32 vs. 6.35%). The ash content of *V. doniana* ranged from 12.99 to 20.53%. The fresh sample had the least (12.99%). Both the sun and the shade dried samples had high and comparable values (20.51 and 20.53%, respectively) ($p > 0.05$).

The fat values for *V. donian* varied. The variation was from 1.66 to 2.36%. The fresh had the least (1.66%). The sun dried sample had the highest (2.36%) and the shade dried had 1.85%. Both the sun and the shade dried samples had higher values than the fresh sample (2.36, 1.85 vs. 1.66%, each) ($p < 0.05$). Sun and shade drying influenced the fibre content of *V. doniana* vegetable. The fresh (FVD) had the least fibre (12.39%). The value for the sun dried sample was 20.48% and that of the shade dried was 21.16%. Shade drying had slight edge over sun drying (21.16 vs. 20.48%). The value for both the sun and the shade dried samples were higher than that of the fresh (12.39%) ($p < 0.05$) (20.48 and 21.16 vs. 12.39%).

The carbohydrate (CHO) content of *V. doniana* had varied values dissimilar to that of fibre. The sun and the shade dried samples had 29.95 and 37.14% CHO, each. The fresh sample had higher value (47.38%) relative to those of sun and shade dried samples (29.95 and 37.14%) ($p < 0.05$). The difference in CHO between these two samples was 7.19%. This was significant ($p < 0.05$). The caloric values for three samples of *V. donina* differed widely ($p < 0.05$). The fresh sample (FVD) had the highest (194.30Kcal). The sun dried sample had 472.18Kj. However, the value for the sun and shade dried sample were 122.6 and 152.28 Kcal, each. The shade dried samples surprisingly had much more calorie than the sun

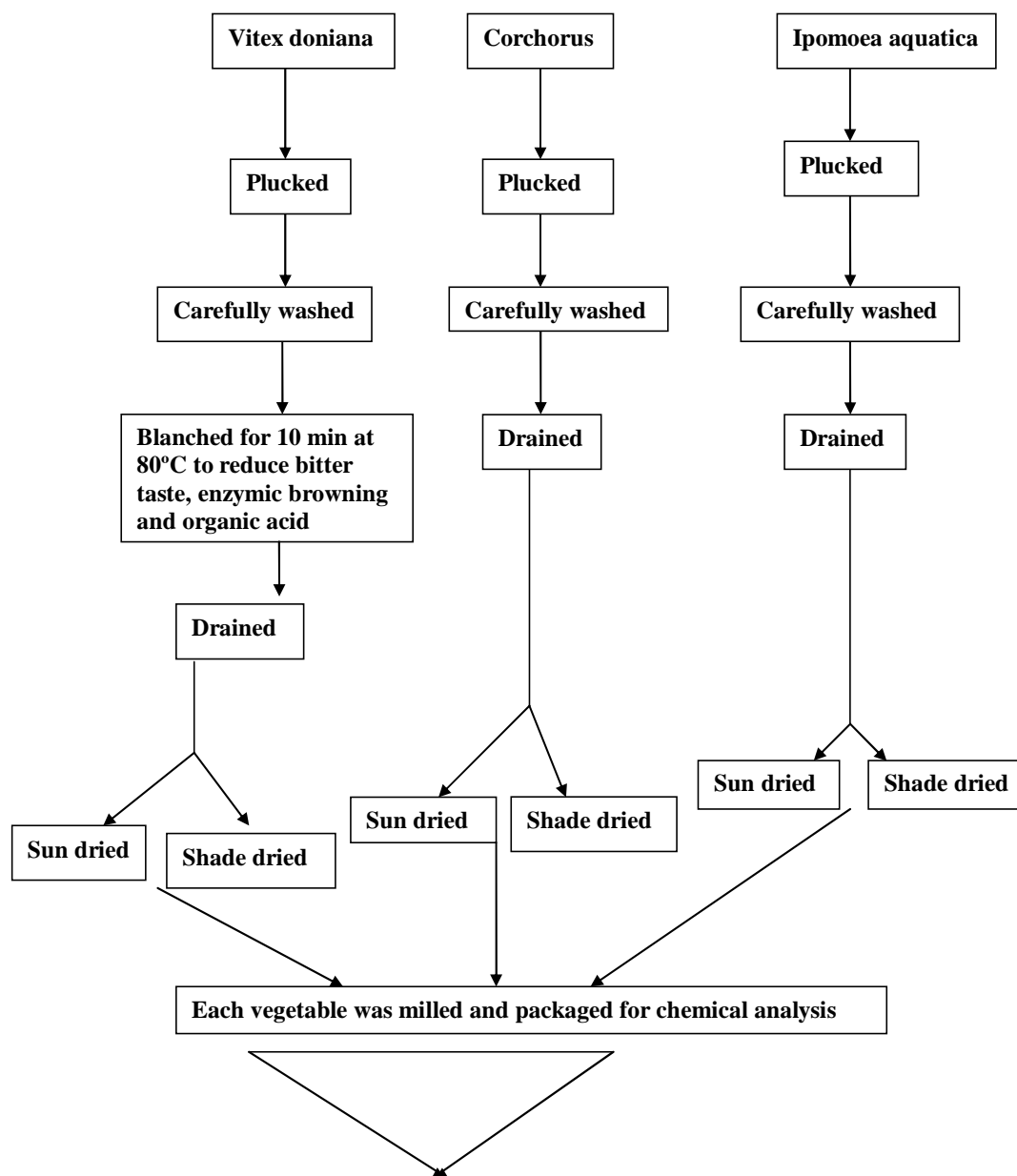


Figure 1. Processing procedures for each vegetable.

dried.

The protein value for corchorus varied. The variation was influenced by sun and shade drying. The fresh sample (FCR) had the highest (25.62%). On the other hand, the sun (SDCR) and the shade (SHDCR) dried samples had comparable protein (6.46 and 6.76%, each) regardless of treatments ($p > 0.05$).

The ash values differed. The value ranged from 14.36 to 20.48%. The sun dried sample had 18.98% as against 20.48% for the shade dried sample. Both sun and shade drying increased ash, however, shade drying had an

edge over sun drying (20.48% vs. 18.99%). The difference was not significant ($p > 0.05$). The fat content of corchorus ranged from 1.55 to 2.38%. As one would expect, the fresh sample (FCR) had the least (1.55%). The sun and the shade dried samples had each 2.08 and 2.38%.

The shade dried sample had more fat than the sun dried sample (2.38 vs 2.08%). There was a slight difference of 0.30% which was not different ($p < 0.05$).

The fibre values differed. The range was from 12.74 to 20.70%. The fresh (FCR) sample had much lower value

Table 1. Effect of processing on proximate composition and caloric value of three green leafy vegetables (%) dry matter basis.

Sample	Protein	Ash	Fat	Fibre	CHO	Caloric value (Kcal/g)
FVD	25.91±0.01 ^a	12.99±0.04 ^d	1.66±0.04 ^c	12.39±0.05 ^c	47.38±0.13 ^d	194.03 ^d
SDVD	6.68±0.13 ^a	20.51±0.03 ^a	2.36±0.05 ^a	20.48±0.03 ^a	29.95±0.04 ^a	122.64 ^e
SHVD	6.35±0.04 ^c	20.53±0.04 ^a	1.85±0.04 ^b	21.16±0.04 ^a	37.14±0.06 ^e	152.29 ^{de}
FCR	25.62±0.01 ^a	14.36±0.14 ^c	1.55±0.30 ^c	12.74±0.05 ^c	45.04±0.58 ^c	184.69 ^d
SDCR	6.46±0.04 ^a	18.98±0.05 ^b	2.08±0.03 ^b	19.98±0.04 ^b	53.41±0.15 ^a	84.72 ^f
SHDCR	6.76±0.14 ^c	20.48±0.04 ^a	2.38±0.05 ^a	20.70±0.03 ^a	51.16±0.03 ^c	209.74 ^c
FIP	22.83±0.16 ^b	11.84±0.04 ^d	1.23±0.02 ^c	12.09±0.04 ^c	52.87±0.05 ^b	216.78 ^a
SIPA	5.95±0.06 ^d	18.77±0.05 ^b	2.63±0.05 ^a	21.06±0.05 ^a	52.93±0.04 ^b	214.81 ^a
SHIP	5.93±0.07 ^d	19.81±1.91 ^a	2.50±0.05 ^a	21.15±0.03 ^a	52.04±0.03 ^b	213.15 ^b

Mean ±SD of three determinations. Samples within the same column with the same superscript are not significantly different ($p > 0.05$). *Dry weight basis. FVD = Fresh *Vitex doniana*, SDVD = sun dried *Vitex doniana*, SHVD = Shade dried *V. doniana*, FCR = Fresh *Corchorus*, SDCR = Sun dried *Corchorus*, SHDCR = Shade dried *Corchorus*, FIP = Fresh *I. aquatica*, SIPA = Sun dried *I. aquatica*, SHIP = Shade dried *I. aquatica*.

12.74% than those of the sun and the shade dried values (19.98 and 20.70 vs. 12.74% ($p < 0.05$)). The shade dried sample had 0.72% more fibre than the sun dried sample (20.70 vs. 19.98%). The difference in fibre between the two samples was significant. The CHO content of *Corchorus* samples ranged from 45.04 to 53.41% ($p < 0.05$). The fresh *Corchorus* had 45.04% CHO, on the other hand, the sun and the shade dried samples had 53.41% and 51.16%. Even if Sun drying increased CHO much more in *Corchorus* than shade drying, the increase was comparable ($p < 0.05$) (53.41 vs. 51.16%). The caloric values for *Corchorus* sample were a function of treatments. The values ranged from 122.6 to 194.30 Kcal. The fresh *corchorus* had the highest energy (194.30 Kcal). The sun dried sample had the least 122.64 Kcal and the shade dried had 152.28 Kcal. Sun drying decreased energy relative to the higher value for shade dried samples (152.28 vs. 122.64 Kcal ($p < 0.05$)).

The protein content of *I. aquatica* ranged from 5.93 to 22.83%. The fresh sample (FIP) had more than twice protein of both the sun and the shade dried samples 22.83 vs. 5.95 and 5.93%, each ($p < 0.05$). On the other hand, the sun and shade dried samples had comparable values (5.95 and 5.93%) ($p > 0.05$). The ash values for *I. aquatica* samples ranged from 11.84 to 19.81%. The fresh sample had the least 11.84%. The shade dried (SHIP) sample had the highest ash (19.81%) and the sun dried sample (SIPA) had the second highest (18.77%). Both the sun and shade dried samples had similar values ($p < 0.05$). The fat values for *I. aquatica* samples ranged from 1.23 to 2.63%. The fresh sample (FIP) had the least fat (1.23%). On the other hand, both the sun and the shade dried samples had each 2.63 and 2.50% fat.

The fibre content of *I. aquatica* samples varied. The range was from 12.90 to 21.15%. The sun (SIPA) and the shade dried (SHIP) samples had comparable values (21.06 and 21.15%, each). The fresh (FIP) sample had the least fibre (12.09%) CHO values for *I. aquatica* differed. The differences were associated with sun and

shade drying of the samples. The range for CHO was from 52.04 to 52.87%. The sun and the shade dried samples had higher and comparable values (52.39 and 52.04%) and the fresh sample had the highest CHO (52.87%). The caloric values of *I. aquatica* varied. The range was from 213.15 to 216.78 Kcal. The fresh sample (FIP) had the highest energy (216.78 Kcal). The sun and the shade dried samples had comparable values (214.81, and 213.15 Kcal).

Table 2 presents the effect of processing on micro-nutrient content of three green leafy vegetables (mg/100g). The calcium (Ca) content of *V. doniana* samples varied. The fresh (FVD) had the highest Ca (12.86 mg). The sun and the shade dried samples had values that were very much lower than that of the fresh sample (0.16 and 0.13 vs. 12.86 mg, respectively) ($p > 0.05$). On the other hand, shade drying (SHVD) reduced calcium more than sun drying (0.13 vs. 0.16 mg). The iron (Fe) content of *V. doniana* samples differed. The differences ranged from 0.07 to 1.33 mg. The fresh (FVD) sample had the highest Fe (1.33 mg). Both sun and shade drying decreased Fe value from 1.33 to 0.07 mg. Sun drying decreased Fe in *V. doniana* much more than shade drying (0.07 vs. 0.10 mg).

Zinc values followed a different trend as against that of iron. The values ranged from 0.08 to 0.4 mg. The Fe value for the fresh (FVD) was the highest (0.40 mg). On the other hand, sun and shade drying caused insignificant and comparable increase in Fe ($p > 0.05$). The values for both processed samples were from 0.08 to 0.40 mg. Both processes had equal effect on Fe content of the samples (0.08 mg).

The iodine values differed for *V. doniana* samples. The range was from 22.07 to 31.74 mg. Both sun and shade drying increased iodine in *V. doniana*. Shade drying increased iodine much more than sun drying (27.72 and 22.07 mg) ($p > 0.05$). The increase was 5.65 mg. The fresh sample had the highest iodine (31.74 mg). The pro-vitamin A (B-carotene) values for *V. doniana* reacted

Table 2. The effects of processing on micronutrient composition of three green leafy vegetables dry weight basis (mg/100g, dry matter basis).

Samples	Ca	Fe	Zn	I	B-carotene	Ascorbic Acid
FVD	12.86±0.01 ^b	1.33±0.05 ^b	0.40±0.06 ^a	31.74±0.01 ^b	322.60±0.32 ^a	225.31±0.33 ^c
SDVD	0.16±0.05 ^c	0.07±0.04 ^c	0.08±0.06 ^c	22.07±0.50 ^b	9.64±0.32 ^e	1.73±0.32 ^f
SHVD	0.13±0.05 ^c	0.10±0.05 ^c	0.08±0.06 ^c	27.72±0.00 ^c	8.52±0.32 ^e	1.75±0.32 ^f
FCR	14.77±0.03 ^a	4.05±0.05 ^a	0.40±0.06 ^a	30.95±0.01 ^b	179.34±0.09 ^c	465.94±0.32 ^a
SDCR	0.14±0.03 ^b	0.10±0.06 ^c	0.00±0.00 ^d	26.41±0.00 ^d	0.20±0.27 ^f	2.75±0.00 ^e
SHDCR	0.12±0.12 ^b	0.08±0.04 ^b	0.07±0.06 ^d	25.30±0.00 ^d	0.20±0.56 ^f	3.24±0.00 ^d
FIP	13.14±0.05 ^b	1.05±0.05 ^b	0.00±0.00 ^d	54.90±0.20 ^a	314.62±0.32 ^b	302.28±0.32 ^b
SIPA	0.13±0.04 ^c	0.07±0.04 ^c	0.00±0.00 ^d	27.75±0.01 ^c	25.93±0.32 ^d	2.07±0.00 ^d
SHIP	0.10±0.05 ^d	0.10±0.03 ^c	0.11±0.06 ^b	24.71±0.46 ^e	27.65±0.32 ^d	2.41±0.36 ^d

Means±SD of three determinations. **dry matter basis Samples with the same superscript in the same column are not significantly different ($p>0.05$). FVD = Fresh *V. doniana*, SDVD = Sun dried *V. doniana*, SHVD = Shade dried *V. doniana*. FCR = Fresh *Corchorus*, SDCR = Sun dried *Corchorus*, SHDCR = Shade dried *Corchorus*, FIP = Fresh *I. aquatica*, SIPA = Sun dried *I. aquatica*, SHIP = Shade dried *I. aquatica*.

differently to both sun and drying. These processes decreased the value from 322.60 to 8.52 mg. Shade drying caused much more decrease (9.64 mg) than sun drying (8.52 mg). The fresh sample had the highest value (322.6 mg). The ascorbate content of *V. doniana* varied. The range was from 1.73 to 225.31 mg. The fresh (FVD) sample had the highest ascorbate (225.31 mg). On the other hand, the sun and the shade dried samples had the least and comparable value (1.73 and 1.75 mg each). Both processing methods had equal effect on ascorbate value.

The calcium (Ca) content of *Corchorus* varied. It ranged from 0.12 to 14.77 mg. The shade dried (SHDCR) sample had the least Ca (0.12 mg). The fresh (FCR) had the highest value (225.31 mg) and differed from the processed samples ($p<0.05$). Sun drying slightly reduced calcium more than shade drying (0.14 vs. 0.12 mg). The Fe values for *Corchorus* differed. The differences were controlled by processing methods. The fresh (FCR) sample had 4.05 mg Fe. On the other hand, the sun and the shade dried samples had 0.10 and 0.08 mg each, Shade drying slightly reduced Fe (0.08 mg) more than sun drying (0.10 mg). The zinc values differed. The range was from 0.00 to 0.40 mg. Sun drying adversely reduced Zinc to zero (0.00 mg). On the other hand, shade drying increased Zinc content of *Corchorus* from 0.00 to 0.07 mg. Both fresh (FCR) and shade dried (SHDCR) samples had varied values (0.40 and 0.07 mg each). The iodine value for *Corchorus* varied. The variation was from 30.95 to 26.41 and 25.30 mg, each). The values for both processed samples were comparable and differed from that of the fresh sample (26.41 and 25.30 vs. 30.95 mg) ($p<0.05$). Shade drying increased iodine (26.41 mg) more than sun drying (25.30 mg), However the difference was insignificant ($p>0.05$). Iodine for *I. aquatica* (FIP) fresh was 54.90 mg and those of sun and shade dried were 27.75 and 24.71 mg, each. Fresh sample had higher value than those of the processed (54.90 vs 27.75 and

24.71 mg each ($p<0.05$).

The pro-vitamin A (B-Carotene) content of *Corchorus* samples differed. It ranged from 8.52 to 322.60 mg. Both the sun and the shade dried samples had lower and equal values (9.64 and 8.52 mg). The fresh (FCR) had extremely higher value than those of the processed samples (322.60 vs. 9.64 and 8.52 mg ($p<0.05$)). The ascorbate values followed the same trend as provitamin A. Both sun and shade drying drastically reduced the value from 225.31 to 1.73mg. Sun drying caused slight decrease in ascorbate more than shade drying (1.73 vs. 1.75 mg) the difference was not significant ($p>0.05$). The fresh sample had much ascorbate concentration than the processed samples (225.31 vs. 1.73 and 1.75 mg, each) ($p<0.05$).

The calcium content of *I. aquatica* ranged from 0.10 to 13.14 mg. The fresh (FIP) had the highest value (13.14 mg). The sun and the shade dried samples had each 0.13 and 0.10 mg. The shade dried (SHIP) sample had the least as against those of the fresh and sun dried samples (0.10 vs 0.13 and 13.14 mg, each). The Fe content of *I. aquatica* varied. It ranged from 0.07 to 0.13 mg. The sun dried sample had 0.07 mg which was lower than that of the shade dried sample (0.10 mg). However, the fresh (FIP) had the highest (1.05 mg). This value was higher than those of the sun and shade dried samples (1.05 vs 0.10 and 0.07 mg) ($p>0.05$).

The zinc content of *I. aquatica* varied. It ranged from 0.00 to 0.11 mg. Both the fresh (FIP) and the sun dried (SIPA) sample values for zinc was (0.00 and 0.00 mg). On the other hand, the shade dried (SHIP) sample had 0.11 mg zinc.

The iodine content of *I. aquatica* ranged from 24.71 to 54.90 mg. The fresh (FIP) sample had 54.90 mg as against those of the sun and the shade dried samples (54.90 vs. 27.75 and 24.71 mg). The sun dried value was the second highest (mg) followed by that of the shade dried (24.71 mg). Based on the result, sun drying

Table 3. Effect of processing on Chemical content of soup meals based on *Vitex doniana*, *Corchorus* and *I. aquatica* vegetables (%), and dry matter basis.

Sample	Protein	Ash	Fat	Fibre	CHO	Cal. Value (Kcal/g)
FVDS	16.51±0.04 ^c	12.60±0.03 ^a	7.15±0.05 ^d	12.38±0.05 ^a	51.28±0.20 ^b	210.24 ^c
SDVDS	18.64±0.02 ^a	12.76±0.08 ^a	8.26±0.05 ^a	11.36±0.05 ^c	48.66±0.06 ^b	199.52 ^e
SHVS	16.27±0.04 ^c	12.13±0.03 ^b	7.81±0.04 ^d	13.37±0.03 ^a	50.69±0.05 ^b	207.70 ^a
F CRS	14.06±0.04 ^d	12.93±0.05 ^a	8.06±0.06 ^c	12.80±0.61 ^a	54.41±0.06 ^a	222.89 ^a
SD CRS	15.07±0.04 ^d	12.18±0.04 ^b	7.26±0.09 ^d	13.38±0.04 ^a	52.41±0.04 ^b	214.87 ^c
SH CRS	16.52±0.03 ^c	12.53±0.06 ^a	10.18±1.36 ^a	11.48±0.05 ^b	52.03±0.04 ^b	217.70 ^b
FIPS	16.14±0.18 ^c	13.76±0.03 ^a	7.82±0.01 ^b	12.83±0.04 ^a	46.65±0.10 ^d	191.26 ^e
SIPS	18.58±0.05 ^a	11.50±0.06 ^b	9.35±0.05 ^b	12.56±0.61 ^a	48.85±0.08 ^c	200.30 ^d
SHIS	17.67±0.04 ^b	11.52±0.05 ^c	9.10±0.05 ^b	12.36±0.08 ^b	49.68±0.03 ^c	203.67 ^d

Mean±SD of three determinations. Sample within the same column with the same superscript are not significantly different ($p>0.05$). FVDS = Fresh *V. doniana* Soup, SDVDS = Sun dried *V. doniana* soup. SHVS = Shade dried *V. doniana* soup. F CRS = Fresh *Corchorus* Soup. SD CRS = Sun dried *Corchorus* soup. SH CRS = Shade dried *Corchorus* soup. FIPS = Fresh *I. aquatica* soup. SIPS = Sun dried *I. aquatica* soup. SHIS = Shade dried *I. aquatica* soup.

appears to be a better method of processing *Ipomoea aquatica* vegetable to increase and retain its iodine concentration. The pro-vitamin A (B- carotene) content of *I. aquatica* differed. It ranged from 25.93 to 314.62 mg. The fresh sample had the highest (314.62 mg). Shade drying had an edge over sun drying (27.65 vs. 25.93 mg). The ascorbate content of *I. aquatica* samples differed. It ranged from 2.07 to 302.28 mg. The fresh sample had the highest ascorbate (302.28 mg). Both sun and shade drying drastically reduced ascorbate from 302.28 to 2.41 and 2.07 mg, each. However, sun drying reduced ascorbate (2.07), much more than shade drying (2.41 mg) as against that of the fresh (302.28 mg)

Table 3 presents the effect of processing on chemical content of soup meals based on *V. doniana*, *Corchorus* and *I. aquatica* vegetables. The protein content of soup meal based on *V. doniana* vegetable varied. The range was from 16.27 to 18.64%. Again, the soup based on sun dried *V. doniana* (SDVS) vegetable had the highest protein (18.64%). The protein values for the soup based on fresh (FVDS) and the shade dried (SHVS) vegetables had comparable protein (16.51 and 16.27%). The ash values differed. It ranged from 12.13 to 12.76%. The soup based on shade dried (SHVS) vegetable had the least ash (12.13%). The soup based on sun dried (SDVS) vegetable had value that was higher than that of the fresh (FVDS) soup 12.13 and comparable to that of fresh (12.76 vs. 12.60%). The fat for *V. doniana* soup varied. It ranged from 7.15 to 8.26%. The soup based on sun dried (SDVS) vegetable had increased fat (8.26%). However, it was comparable to that of the fresh (FVDS) soup (7.81 vs. 7.15%). The latter soup had the least fat (7.15%).

The fibre content of *V. doniana* soup meals varied. The range was from 11.36 to 13.37%. The sun dried (SDVS) soup had the least fibre (11.36%). The soup based on fresh (FVDS) vegetable had 12.88% fibre. The soup meal based on shade dried (SHVS) vegetable had the highest

value which might be similar to that of the fresh (FVDS) soup (13.37%). The CHO content of *V. doniana* based soups varied. The variations were insignificant (51.28, 48.60 and 50.69%, each). The energy content of *V. doniana* based soup meals varied. The range was from 199.52 to 210.24 Kcal. The soup based on fresh (FVDS) vegetable had the highest value (210.24 Kcal) followed by that based on shade dried (SHVS) vegetable (207.70 Kcal). The soup based on sun dried (SDVS) vegetable had the least energy (199.52 Kcal).

Protein for *Corchorus* soups varied. The variation was from 14.06 to 16.52%. The shade dried (SH CRS) soup had the highest protein 16.52% followed by that of the sun dried (SD CRS) vegetable soup (15.02%). Both the sun and the shade dried soups had more protein than that of the fresh (F CRS) soup meal (15.07 and 16.52 vs. 14.00%, each). The ash value for the sun and the shade dried (SD CRS and SH CRS) soups were lower than that of the fresh (F CRS) soup (12.48 and 12.53 vs. 12.93%). The sun and shade dried (SD CRS and SH CRS) based soups had comparable values (12.48 and 12.53%) The fat values for the *Corchorus* soups varied. The soup based on fresh corchorus (F CRS) had 8.06% fat. The sun dried (SD CRS) soup had the least (7.26%). On the other hand, the shade dried (SH CRS) based soup had the highest fat (10.12%).

The fibre values for all soups based on *Corchorus* were high and varied. The range was from 11.48 to 11.46%. The sun dried (SD CRS) based soup had the least (11.48%). The sun dried (SD CRS) soup had the highest fibre (13.46%) which was slightly higher than that of the fresh (F CRS) vegetable based soup (12.38%). The CHO values for soups based on *V. doniana* vegetable varied. The soup based on fresh (FVDS) vegetable had highest (51.28%) followed by that of the soup based on shade dried (SHVS) vegetable (50.69%). The sun dried (SDVS) soup had the least (48.66%). The values for the fresh and

Table 4. Minerals and antinutrients content of soups based on fresh, sun and shade dried green leafy vegetables (mg/100 g).

Sample	Ca	Fe	Zn	I	Phytate	Tannins
FVDS	0.12±0.03	0.08±0.04	0.06±0.05	22.47±0.10	7.17±0.61	0.13±0.04
SDVS	0.11±0.04	0.07±0.03	0.07±0.04	21.61±0.01	6.19±0.03	0.13±0.04
SHVS	0.08±0.03	0.12±0.04	0.07±0.04	23.00±0.01	7.65±0.04	0.11±0.03
F CRS	0.10±0.04	0.08±0.05	0.00±0.00	23.80±0.00	6.92±0.04	0.17±0.04
SD CRS	0.11±0.04	0.10±0.04	0.00±0.00	11.51±0.00	6.60±0.04	0.12±0.04
SH CRS	0.12±0.04	0.13±0.04	0.00±0.00	12.04±0.00	6.66±0.04	0.14±0.04
F IPS	0.10±0.05	0.08±0.05	0.00±0.00	29.39±0.00	6.56±0.05	0.11±0.05
S IPS	0.11±0.04	0.07±0.03	0.00±0.00	22.13±0.01	7.03±0.04	0.15±0.04
SH IPS	0.11±0.04	0.010±0.27	0.00±0.00	22.41±0.01	6.81±0.04	0.08±0.0

Mean± SD of three determinations *** Dry matter basis. FVDS = Fresh *V. doniana* soup. SDVS = Sun dried *V. doniana* soup. SHVS = Shade dried *V. doniana* soup. F CRS = Fresh *Corchorus* soup. SD CRS = Sun dried *Corchorus* soup. SH CRS = Shade dried *Corchorus* soup. F IPS = Fresh *I. aquatica* soup. S IPS = Sun dried *I. aquatica* soup. SH IPS = Shade dried *I. aquatica* soup.

the shade dried based soups were comparable (51.28 vs. 50.69%). The energy content of the soups varied. The range was from 199.52 to 210.24 kcal. The sun dried vegetable soup had the least 199.52 Kcal. The soup based on fresh (FVDS) and shade dried (SHVS) vegetables were 210.24 and 207.70 Kcal, respectively.

The protein values for *I. aquatica* also deferred. The soup based on sun dried (SIPS) had the highest protein (18.58%) followed very closely by that of the shade dried (SHIS) (17.67%). The soup based on fresh (FIPS) had the least protein (16.14%). Both treatments of the vegetables influenced protein content. However, sun drying increased protein more than shade drying. The difference in protein was less than 1.0% (0.91%) (18.58 to 17.67%). The ash values established an interesting trend. The range was from 11.52 to 13.76%. The soups containing the sun and the shade dried Ipomoea vegetable had similar values (11.52 and 11.50%). The soup based on fresh (FIPS) had more ash than any of the soups based on either sun or shade dried vegetable (13.76 vs. 11.52 and 11.50%). The fat values for the soups differed. The range was from 7.82 to 8.40%. On the other hand, the soups based on the sun or the shade dried vegetable had comparable fat (9.35 and 9.10%) which was higher than that of the fresh (FIPS) (7.82%).

The fibre values for the three soups based on fresh, sun and shade dried vegetables (FIPS, SIPS and SHIS) had comparable values (12.83, 12.56 and 12.33%, respectively). The CHO content of these soups had a similar trend as that of fibre. The fresh (FIPS), the sun dried (SIPS) and the shade dried (SHIS) soup had each 46.65, 48.85 and 49.68%, CHO). The soup based on fresh (FIPS) had the least CHO (46.65%). The CHO content of the soup based on shade dried vegetable (SHIS) soup had an edge over that of the sun dried (SIPS) soup (49.68 vs. 48.85%). The difference was only 0.83% (49.68 to 48.85%). The energy content of the soups based on fresh, sun and shade dried *I. aquatica* leaves varied. The range was from 191.26 to 203.67 Kcal. The soup prepared with fresh (FIPS) vegetable had

the least energy (191.26 Kcal) followed by that of the soup prepared with sun dried (SIPS) vegetable (200.30 Kcal). On the other hand, the soup prepared with shade dried (SHIS) vegetable had the highest energy (203.67 Kcal).

Table 4 presents the effect of processing on minerals and anti-nutrients content of soups based on three green leafy vegetables (mg/100g). The calcium, iron, zinc, iodine, phytate and tannins content of the soup meals whether or not the vegetable was fresh, sun or shade dried were comparable ($p > 0.05$). (Table 4). Zinc content of both *Corchorus* and *I. aquatica* soups were in traces or zero values. The iodine values for *V. doniana* soup meals differed. The ranged was from 21.61 to 23.00 mg. The SHVS soup had little edge over the FVDS and the SDVS soups (23.00 vs 22.47 and 21.61 mg). The difference was not significant ($p > 0.05$). The soup prepared with fresh (FIPS) had the highest iodine (29.39 mg). On the other hand, the soups prepared with the sun (SD CRS) or the shade dried (SH CRS) *Corchorus* had each 11.51 and 12.04 mg). The difference in iodine between the two soups was only 0.60 mg. The phytate and tannins content of the soups were high and comparable (phytate 6.60 to 6.92 and tannins 0.12 to 0.17 mg, each).

The calcium, iron, zinc, iodine and tannins, content of the soups based on fresh (FIPS) sun dried (SIPS) and shade dried (SHIPS) had similar values. On the other hand, these soups had varying values for iodine and phytate. The values for iodine ranged from 22.13 to 29.39 mg and that of phytate ranged from 6.56 to 7.03 mg, respectively,

DISCUSSION

Moisture content is an index of stability of food. The amount of moisture in a food affects its keeping quality, the nutrients provided, type and rate of microbial spoilage (Bollin and Stafford, 1974). The general increases in

protein, ash, fat, fibre, carbohydrate and energy were due to loss of moisture. (The values were expressed on dry matter basis to allow for necessary comparisons). Moisture loss is associated with increase in dry matter of which these nutrients are among. The lower fat for all the processed vegetables based on dry matter have some nutrition implications. Lower moisture increases both nutrients and shelf life. Lower fat in any given food reduces chances of rancidity- a commonly observed fact (Oguntona, 1988). Thus, increase in consumption of vegetables (*V. doniana*, *I. aquatica* and *Corchorus*) would naturally lower the percentage of total fat intake. More importantly, no cholesterol is found in fruits and vegetables (Akubo et al., 2009), vegetables are known to contain very small amount of fat to maintain cell wall integrity.

The much lower protein (6.35%) for the shade dried SHVD) *V. doniana* than that of the sun dried (SDVD) 11.32mg sample appeared to indicate the superiority of sun drying to increase and retain more protein than shade drying (11.32 vs. 6.35%). ($p < 0.05$) The higher ash (20.53%) for the shade dried (SHVD) sample than that of the sun dried (SDVD) (20.51%) showed that sun drying slightly increased ash in *V. doniana* sample than shade drying, however the difference was comparable ($p > 0.05$). The lower fat for fresh (FVD) samples (12.99%) showed that fresh (FVD) samples had better chance of longer keeping quality and free of rancidity – a commonly observed phenomenon (Xiao et al., 2000). The higher fibre for the sun and the shade dried samples was not a surprise. Loss of moisture increases dry matter of which fibre is one. This value was based on free moisture. High fibre content of foods is good for quick bowel evacuation. The high fibre consumption is known to reduce the risk of colon cancer (Afarm, 2003). The lower value (12.39%) for fresh (FVD) sample further showed that fresh vegetables are not better sources of dietary fibre than those of the processed samples (12.39 vs. 20.45 and 21.16%, each) ($p < 0.05$). The lower carbohydrate and energy (47.38% and 194.30 Kcal) for fresh *V. doniana* (Table 1) was expected. This is because vegetables in general are poor sources of carbohydrate and energy. On the other hand, the two food processing techniques increased the values as against their controls (29.95% and 122.64 Kcal and 37.14% and 152.28 Kcal vs. 47.38% and 194.30 Kcal (Table 1).

The higher protein for fresh *Corchorus* 25.62% was not surprising. Fresh vegetables contains more moisture, however, when based on moisture free, their dry matter is increased of which protein is among. The lower value for the fresh sample (6.46 and 6.76%) (Table 1) for the two processed samples relative to higher value (25.62%) for the fresh sample demonstrated that any of the processing methods would decrease the nutrients in these vegetables. On the other hand, the lower ash, fat, fibre, carbohydrate and energy for fresh *Corchorus* and *I. aquatica* (14.36, 1.55, 12.74, 45.04% and 184.69 Kcal as

well as 11.84, 1.23, 12.09, 52.87% and 216.78 Kcal, respectively) showed that fresh vegetables are not good sources of these nutrients and energy.

The higher calcium, iron, zinc, iodine, B-carotene and ascorbate for all the three vegetables (Table 2) showed that these micronutrients are much more concentrated in fresh vegetables relative to their processed counterparts. The decreases in sun and shade dried samples particularly in Beta carotene and ascorbate were due to loss during heat treatment for fresh vegetables than dried because they are volatile in nature. The higher calcium (2.19, 2.13 and 1.94 mg) for the three vegetables showed that they are good sources of calcium. The lower values for the dried samples indicated that none of the drying method had the potential to increase calcium in these vegetables.

The higher B-carotene (322.60, 179.34 and 314.62 mg) for fresh samples, against dried (27.65, 8.52 and 0.20) demonstrated that the nutrient (pro-vitamin A) was much more concentrated in fresh samples than in dried. The lower B-carotene was not a surprise, because B-carotene and its relative derivatives are known to be volatile when exposed to mild heat. Base on this, drying might have led to the loss of B-carotene during processes (Udofia and Obizoba, 2005; Wachap, 2005) had experienced the same phenomenon in various fresh green leafy vegetable they investigated.

The lower ascorbate for the three dried vegetable samples relative to their fresh (controls) was solely attributable to the treatments. Ascorbate is water soluble and volatile when heated. It might be that the heat generated during drying caused the loss. Ascorbic acid assists iron absorption while B-carotene promotes human eyesight. Udofia and Obizoba (2005) and Zimmermann et al. (2003) reported similar observations. On the other hand, the low zinc (0.40 mg) content of the fresh *V. doniana* (FVD) showed that the vegetable contains little or traces of zinc minerals. The lower values for iodine for the sun and the shade dried samples (Table 2) 22.07 and 27.72 mg against 31.74 mg for *V. doniana*; 21.41 and 25.30 mg against 30.95 mg for *Corchorus* and 27.75 and 24.71 mg against 54.43 mg for *I. aquatica*, showed that iodine would be high in diets that contain these vegetables in their dry forms.

The higher protein (18.64%) content of the soup prepared with sun dried vegetable was because of heat lower moisture (Table 1) relative to its control (fresh) prior to its use for soup preparation. The soups prepared with the sun and the shade dried *I. aquatica* (SIPS and SHIS) vegetables had lower and comparable ash (11.50 and 11.52) (Table 3) than the other soups prepared with the sun or the shade dried samples. The higher fat content of soups prepared with traditional recipes that called for addition of palm oil, led to the increase in fat of each soup meal.

The high fiber content of all the soup meals was because the dried vegetables had increased fibre due to

loss of moisture. In addition, the food condiments contained extra fibre in addition to those in vegetables. The less than 50% carbohydrate content of the soups is simple to explain. Naturally, vegetables are not good sources of carbohydrate. The values contained in these soups might be those from soup thickeners. The fair levels of energy content of the soups might be associated with the added soup thickener and palm oil based on carbohydrate foods such as yam or cocoyam as the case may require.

The general low calcium, iron and zinc content of the soup meals (Table 4) was because the vegetables used for these soups preparation had low values for these minerals. The food condiments also did not contain these minerals as to add to those in vegetables. On the other hand, the high iodine values for the soups were because the vegetables prior to their use for soup preparation had high levels of this nutrient. The slightly high levels of phytate and tannins in these soups have some nutrition and health implications. Formally, these plant chemicals were regarded as anti-nutrients because they chelate some macro-elements to precipitate their un-bioavailability. However, recent information regards these as phytochemicals. They are now involved in series of reactions to lower serum cholesterol levels. Not only this, they may participate in the processes of reducing or lowering cancer risks (Vainio and Bianchini, 2003).

Indigenous vegetables constitute very important sources of minerals and vitamins in Nigeria diet. The high fibre content of the analyzed vegetables suggests that they can provide excellent sources of roughage which help to promote digestion of food. Therefore, vegetables provide significant percent of minerals and vitamins, for the average Nigerian's nutrient requirement which could be met through consumption of *V. doniana*, *Corchorus* and *I. aquaticas* for eradication of malnutrition.

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