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The effect of different processing methods on the proximate, *β*- carotene and ascorbate composition of fluted pumpkin (*Telfairia occidentalis*) leaves and its product, the leaf curd

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Abstract: The study examined effect of different processing methods on the proximate, *β*-carotene and ascorbate composition of fluted pumpkin (*Telfairia occidentalis*) leaf and the curd produced from the leaf. Fluted pumpkin leaf was divided into four (4) portions. One was shade-dried, another was sun-dried and the other was used to produce leaf curd. The last portion was not processed and served as the control. All the processed samples were milled to fine flour and analysed using standard assay methods. The results showed that the fresh leaf curd (FLC) sample had the highest protein (26.27%) and the fresh pumpkin leaf (FPL) had the least (11.25%). On the other hand, the dried leaf curd (DLC), the shade-dried and the sun-dried fluted pumpkin leaves had comparable ($p>0.05$) values (19.75 vs 23.08 vs 23.78%). The fat composition of the samples differed. The dried leaf curd samples had the least fat (0.93%) followed by fresh leaf curd (3.03%). The shade dried leaf had the highest fat (ether extract), which was different from others ($p<0.05$). The dried leaf curd had the least ash (1.21%). The fibre composition followed the same trend as that of ash and fat. The fresh pumpkin leaf had the highest ash and fibre (17.72%) and least carbohydrate (CHO) (51.27%). The shade dried and sun-dried fluted pumpkin leaves had comparable ($p>0.05$) ash values (3.47 and 3.00%, respectively) and the dried leaf curd had the least (1.29%). The CHO levels of the samples differed ($p<0.05$). The fresh pumpkin leaves had comparable ($p>0.05$) values (61.30-62.87%). However, the dried leaf curd had the highest CHO (76.99%) ($p<0.05$). The β-carotene level of the samples differed. The values ranged from 0.88 to 83.57 µg/g. The sun-dried samples had significantly lower ($p<0.05$) β-carotene (0.88 µg/g) than the other samples ($p<0.05$). On the other hand, the fresh leaf curd had the highest ($p<0.05$) pro-vitamin A level. Shade-dried samples had higher β-carotene than the sun-dried (41.09 vs 0.88 µg/g). The ascorbate composition of the five samples differed. The dried leaf curd and the sun-dried sample had similar ascorbate (0.16 and 0.18 mg/100g) while the shade dried and fresh leaves had similar ($p>0.05$) levels (0.28 mg/100g respectively). On the other hand, the fresh leaf curd had significantly higher values ($p<0.05$) than the others. These study have revealed the proximate, beta-carotene and ascorbate composition of fluted pumpkin processed in different methods, hence, this is a vital tool in the hand of nutritionist and dietitians for proper management of patients and nutrition education.

Keywords: Processing Methods, Proximate, Beta - Carotene, Ascorbate, Fluted Pumpkin

1. Introduction

A vast majority of individuals in the third world countries are not able to satisfy their nutritional requirements for growth and development. This leads to malnutrition, which is one of the major causes of death, particularly in infants and young children. Malnutrition can manifest as protein-energy malnutrition (PEM) and micronutrient deficiency. Micronutrients are involved in metabolism of energy nutrients and their deficiency may precipitate PEM as well as their specific deficiency diseases.

Despite the approaches on the past geared towards combating micronutrient deficiencies through supplementation in form of drugs, fortification of some food

products and other measures, the problem still exists. This is because most people do not routinely take their supplements as they view it as drug and others abuse it as prescribed. Most of our fortified food products are costly and the poor in the rural communities and the low socio-economic groups cannot afford to purchase them. They depend on their cheaper and low micronutrient familiar unfortified products.

The National Demographic and Health Survey (DHS) from 2008 indicates high levels of moderate to severe stunting in children under five years of age (41%) and moderate to severe wasting (14%). Undernutrition spikes between 3 and 18 months in the DHS 2008 data. This period is a window of opportunity where optimal infant and young child feeding practices can improve lifelong health and economic outcomes. Breastfeeding is almost universal, but exclusive breastfeeding rates are very low, even at 2 or 3 months, and complementary feeding does not include enough times during the day nor enough diversity of food groups [(1)].

Nigeria ranked 8th in the world in the prevalence of mortality rates of under-fives, with a staggering figure of 189/1000 in 2008 [(2)]. The World Health Organization estimates that approximately 150 million children younger than 5 years in developing countries are underweight and an additional 200 million children are stunted. Malnutrition contributes to Nigeria's current health problems (morbidity and mortality) in several ways. Undernutrition remains a devastating problem in many developing countries affecting over 815 million people causing more than one-half of child death [(2 - 5)]. Although, WHO, UNICEF and Nigeria's National breastfeeding policy recommended that infants be exclusively breastfed from birth to 6 months and continue breastfeeding to 24 months and beyond for optimal survival, growth development unfortunately only 17% of infants under six months of age are exclusively breastfed in Nigeria [(6)]. The poor breastfeeding and inadequate complementary feeding explained the protein energy malnutrition level in children as they grow older.

Based on the diverse effects of vitamin A deficiency, it is important that preventive measures capable of combating these deficiencies be adopted, especially diversification of diets at the reach of the low income groups.

The inherent problem of micronutrient deficiency is very difficult to combat because as hidden hunger, it is not easily detected. An estimated 250,000 to 500,000 vitamin A deficient children get blind every year. Half of them die within 12 months of loosing their sight. Nearly 600,000 women die from childbirth-related causes each year, the vast majority of them from complication which could be reduced through better nutrition, including provision of vitamin A supplements. Vitamin A deficiency (VAD) is the leading causes of preventable blindness in children and raises the risk of diseases and death from severe infection. Lack of vitamin A in children causes severe visual impairment and significantly increases the risk of severe infections and death from such common childhood infections as diarrhoea disease and measles [(7 - 8)].

As a result of these life threatening effects of vitamin A deficiencies, there is a need to adopt an intervention programme that would be within the reach of the low socio-economic groups who are mostly affected. Dietary diversification using locally available foods within the communities appears to be a more feasible approach in rural communities than other approaches. The leaf of this crop *Telfairia occidentalis* is an important food vegetable for many people especially in the mid-western and eastern parts of Nigeria. The local names include "ugu" (Igbo) and "iroko" (Yoruba). The crop is a member of the cucurbitaceae family. Characteristically, the male plants produce leaves that are smaller than the female plants and the leaves are divided into 3-5 leaflets. It is a perennial vine with stem that can be as long as 10 meters. *Telfairia occidentalis* originated from tropical West Africa, especially Nigeria, Ghana and Sierra Leone and is grown both for its leaves and for the seeds contained in its large ribbed fruits [(9)] but not for the roots which is reported to be highly toxic and poisonous [(10)]. It has been estimated that approximately 0.5kg of leaves and shoots can be obtained from plants per harvest [(11)] and up to 15 harvests can be obtained between 3-4 months. The leaves are highly cherished as cooked vegetables although the seeds are also used in soups, etc. However, there is no identifiable information on the crop in terms of varieties, harvesting method, oil composition and processing methods [(12 - 13)].

The general objective of the study was to evaluate the fluted pumpkin leaf curd as possible ingredient for the formulation of complementary food. The specific objectives were to:-

(1) determine the proximate composition of differently processed fluted pumpkin leaf (sun and shade-dried fluted pumpkin leaf and the curd).
(2) determine the beta carotene composition of differently processed fluted pumpkin leaf (sun and shade-dried fluted pumpkin leaf and the curd).
(3) determine the ascorbate composition of differently processed fluted pumpkin leaf (sun and shade-dried fluted pumpkin leaf and the curd).

The study will provide baseline information on the beta carotene and ascorbate nutritional value of pumpkin leaf curd for its possible use as ingredients for infant food formulation. The study will shed more light on processing methods that could be used to reduce bulk of locally available vegetables for use in infant feeding. The work will highlight the contribution of leaf curd as possible means of increasing micronutrient density of the locally available vegetables particularly their pro-vitamin A and iron levels.

2. Materials and Methods

2.1. Source of Sample

Fluted pumpkin (*Telfairia occidentalis*) used for the study were purchased from Nsukka main market in Enugu state.

2.2. Preparation of Sample

Fluted pumpkin leaves were picked to remove stems, flowers, unwanted particles, washed in clean deionized water and divided into four equal portions. One portion was analysed fresh which served as control. The other two portions were dried, one under shade and the other under sunlight. The fourth portion was used to produce the leaf curd.

2.3. Preparation of Fluted Pumpkin Leaf Curd

One portion of fresh fluted pumpkin leaves was homogenized in a laboratory homogenizer (HOBART MIXER) to obtain vegetable puree. The puree were mixed with deionized water in a ratio of 1:3 (puree to water) to get a homoginized mixture. The mixture was filtered through a clean cloth to obtain a clean filtrate. The filtrates were simmered at 75OC until the leaf curd was formed. The production of the fluted pumpkin leaf curd is shown in Fig 1.

2.4. Chemical Analysis

Chemical analysis of the following samples were estimated in triplicate

(1) fresh fluted pumpkin leaves
(2) sun- dried fluted pumpkin leaves
(3) shade- dried fluted pumpkin leaves
(4) dried leaf curd
(5) fresh leaf curd.

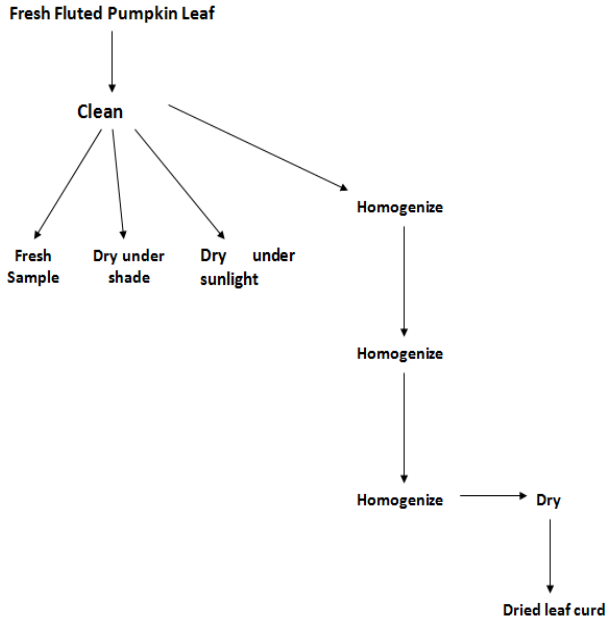

Fig 1. *Flow diagram for leaf curd preparation*

2.5. Proximate Analysis

2.5.1. Crude Protein

Total nitrogen (N) was determined by the official micro-kjedahl method of AOAC [14]. Crude protein was estimated by multiplying nitrogen value with conversion factor 6.25 (N x 6.25).

2.5.2. Digestion

The samples were weighed in triplicates. One gram of the sample was put into Kjedahl flask. Kjedahl salts (Na_2SO_4) were added i.e. the anhydrous and aipric sulphates. Five (5 ml) of the concentrated sulphuric acid was added into each flask. The flask was stoppered and swirled. Each flask was placed on kjedahl digestion rack in a fume chamber and heated for at least 1 hour until the solution is turned clear. The digested samples were allowed to cool sufficiently. A little amount of distilled water was added down the side of the flask with a wash bottle until reaction occurs. The digested samples were made up to 100 ml distilled water.

2.5.3. Distillation

Ten (10) ml of mixed boric acid and methyl red indicator was put into a 50 ml conical flask and placed under the collection spigot of the distillation apparatus. Five (5) ml of 60% sodium hydroxide was added to 5 ml of the digested (100 ml) in the distillation apparatus. The solution was allowed to steam (distilled) for about 5-7 minutes or when the volume of ammonia with the boric acid in the receiver flask measured 50 ml and the solution turned green.

2.5.4. Titration

The green solution in the conical flask was titrated with 0.01N hydroxide acid until the solution turns grey in colour.

Calculation of the percentage (%) crude protein was done using the formula below:

$$\%\ \text{Crude protein} = \frac{\text{Titre value} \times \text{normality of HCl} \times 14.007 \times 6.25 \times 10}{\text{Weight of sample}}$$

2.5.5. Total Lipids

These were estimated using the Pearson modified method (1976) with the Soctec apparatus. About two grams of the samples were weighed and put into already weighed extraction cups. The Soctec apparatus was set accordingly. The samples were extracted with acetone for three hours. The solvent free fat in the cup was dried in an air oven for 30 minutes at 80^{O}C. The cooled cup and content was reweighed.

$$\%\ \text{Fat} = \frac{\text{Weight of extract} + \text{cup} - \text{weight of cup} \times 100}{\text{Original weight of sample}}$$

2.5.6. Total Ash

This were estimated by incineration of known weight of samples in a muffle furnace at 550-600^{O}C using the AOAC [14] procedure. The weights of the crucibles were recorded and 2 g each of the samples were weighed in triplicates. Samples were placed in pre-heated 550^{O}C furnace overnight. The samples were removed and cooled in a dessicator.

Weights of the ashed samples were recorded by using the formula below:-

$$\%\text{Ash} = \frac{\text{Weight of ash + crucible – weight of crucible} \times 100}{\text{Weight of original sample}}$$

2.5.7. Crude Fibre

The crude fibre contents were determined by the official method of AOAC [14]. About 2 g of the samples were weighed into 500 ml beaker. The content was boiled for 30 minutes. It was filtered through a fluted funnel and was washed with boiling water until the washing was no longer acidic. The samples were boiled for 30 minutes with 200 ml sodium hydroxide solution, and were filtered with hot water using muslin cloth; then rinsed with one percent (1%) HCl, and finally with mentholated spirit. The residue that was obtained was collected and dried in an oven for 30 minutes. The contents were cooled in a dessicator and then weighed. These were taken to furnace for ashing at 550^{O}C for 30 minutes. The ashed sample were removed from the furnace after the temperature returned to 200^{O}C and put into the dessicator and later weighed. The loss in weight between the incineration was taken as the crude fibre content.

$$\text{The percentage crude fibre} = \frac{\text{Total weight of fibre} \times 100}{\text{Weight of the sample}}$$

2.5.8. Carbohydrate

This was determined by the difference method. The carbohydrate content was obtained by difference. The percentage of crude protein, crude fibre, fat, ash and moisture was summed. The value obtained was deducted from 100%. The total carbohydrate of each sample represented the difference in value.

CHO = 100 – (% of protein + % of fat + % of ash + % crude fibre + % moisture)

2.5.9. Moisture

This was determined using the AOAC [14]method. Two grams of each sample were weighed into crucible and put into muffle furnace at 550^{O}C for three hours until ash was obtained. The weights of the dishes were recorded and 2 g of each of the samples were weighed in triplicates. They were placed in the oven at 105^{O}C for 6 hours. The samples were removed and cooled in a dessicator. Then the dried samples were weighed.

$$\text{Moisture} = \frac{\text{Weight of sample – weight of dried sample} \times 100}{\text{Weight of sample}}$$

2.6. Vitamin

2.6.1. Pro-Vitamin A Carotenoids

Beta-carotene was determined using AACC [15] method. The samples were washed with organic solvent (chloroform). The absorbances of the filtrate were measured with UN-spectrophotometer at 328nm.

2.7. Carotenoids (RS) (U – Spectrophotometric Method)

2.7.1. Reagents

Cyclohexane, carotenoid (RS).

2.7.2. Principle

The principle is based on the use of UV-spectrophotometric method after ashing with cyclohexane.

2.7.3. Method

The samples were dissolved or a prepared portion in cyclohexane such that it contained 9–15 units per ml and the wavelength of maximum absorption was obtained. The extinctions at the wavelengths were measured and the calculation was on one fraction relative to that at 328 nm. The $E^{1\%}$ cm figure at 328 nm was calculated if the wavelength of maximum absorption is 326-329 nm and the relative observed extinctions were within 0.02.

2.7.4. Calculation

Potency (Unit 1g) $1900 \times E_{328}$ at 328 nm.

The following correction could be applied if the maximum lies in the same ranged but the relative extinctions are within are within 0.02.

2.8. Ascorbate

This was determined using AOAC [14] method. About 2g of each sample was dissolved with distilled water. 2ml of Trichloroacetic acid (TCA) was added and colour were developed with 2,6-dichlorophenol. This colour developed was read with spectrophotometer .

2.8.1. Reagents

A quantity of 0.05g indophenol made up to 100ml. Ten (10 g) grammes of metaphosphoric acid in 200 ml of water. Acetone

2.8.2. Principle

The principle is based on the use of a coloured dye 2, 6-dichloroindophenol to oxidize the ascorbic acid.

2.8.3. Method

A quantity of 0.5 g of solid sample or 0.5 of liquid sample was weighed into a 100 ml volumetric flask; then 5 ml of metaphosphoric acid was added. Then 10ml of the filtrate was taken and 2.5 ml of acetone was added to it and titrated with the indophenol solution to a pink point.

2.8.4. Calculation

$$\frac{a \times (V2 - V1) \times 0.0052}{\text{Weight of sample}}$$

Where:-

a = Volume of filtrate

V_1 = Initial burette reading

V_2 = Final burette reading

2.9. Statistical Analysis

Data collected were subjected to one way analysis of variance (ANOVA). The Least Significance Difference (LSD) tests were used to separate means [16 - 17].

3. Results

Table 1. *Proximate composition of differently processed fluted pumpkin (T. occidentalis) leaves*

Nutrients	FLC	DLC	SHDPL	SDPL	FPL	LSD
Moisture %	76.24^{b}	9.75^{c}	18.50^{c}	16.77^{c}	84.00^{a}	7.534
Crude protein %	6.24^{b}	17.79^{a}	18.76^{a}	19.82^{a}	1.80^{c}	4.040
Fat %	0.72^{c}	0.85^{b}	7.30^{a}	6.70^{a}	0.90^{b}	0.901
Ash %	0.83^{d}	1.09^{c}	2.43^{a}	1.83^{b}	2.40^{a}	0.173
Crude fibre %	1.38^{b}	1.16^{c}	2.82^{a}	2.50^{a}	2.80^{a}	0.851
CHO %	14.56^{c}	69.36^{a}	50.204^{b}	52.39^{b}	8.10^{c}	6.816

n = 3
a-d: Values with the same letters are statistically similar ($p>0.05$) and those with different letters are different ($p<0.05$)
FLC - Fresh leaf curd
DLC - Dried leaf curd
SHDPL - Shade-dried fluted pumpkin leaf
SDPL - Sun-dried fluted pumpkin leaf
FPL - Fresh fluted pumpkin leaf

The moisture level of the samples ranged from 84.00% in fresh pumpkin leaf to 9.75% in dried leaf curd; the crude protein values varied from 19.82 to 1.80%; fat ranged from 7.30 to 0.72%; ash ranged from 2.43 to 0.83%; crude fibre ranged from 2.82 to 1.16% and carbohydrate varied from 69.36 to 8.10%.

Table 2. *Proximate composition of differently processed fluted pumpkin (Telfairia occidentalis) leaves on dry matter basis*

Nutrients	FLC	DLC	SHDPL	SDPL	FPL	LSD
Protein %	26.27^{a}	19.75^{b}	23.08^{b}	23.78^{b}	11.25^{c}	4.03
Fat %	3.03^{d}	0.94^{e}	8.98^{a}	8.04^{b}	5.03^{c}	0.90
Ash %	3.49^{b}	1.21^{e}	2.99^{c}	2.20^{d}	15.0^{a}	0.17
Crude fibre %	5.81^{b}	1.29^{d}	3.47^{c}	3.00^{c}	17.5^{a}	0.85
CHO %	61.30^{b}	76.99^{a}	61.75^{b}	62.87^{b}	50.63^{c}	6.82

n = 3
*a-e: Values with the same letters are statistically similar ($p>0.05$) and those with different letters are different ($p<0.05$)
FLC - Fresh leaf curd
DLC - Dried leaf curd
SHDPL - Shade-dried fluted pumpkin leaf
SDPL - Sun-dried fluted pumpkin leaf
FPL - Fresh fluted pumpkin leaf

Table 2 presents the proximate composition of the five samples of fluted pumpkin leaves on dry matter basis. The fresh leaf curd (FLC) sample had the highest protein (26.27%) and the fresh pumpkin leaf (FPL) had the least (11.25%). On the other hand, the dried leaf curd (DLC), the shade-dried and the sun-dried fluted pumpkin leaves had comparable ($p>0.05$) values (19.75 vs 23.08 vs 23.78%). The fat composition of the samples differed. The dried leaf curd samples had the least fat (0.93%) followed by fresh leaf curd (3.03%). The shade dried leaf had the highest fat (ether extract), which was different from others ($p<0.05$). The dried leaf curd had the least ash (1.21%). The fibre composition followed the same trend as that of ash and fat. The fresh pumpkin leaf had the highest ash and fibre (17.72%) and least CHO (51.27%). The shade dried and sun-dried fluted pumpkin leaves had comparable ($p>0.05$) ash values (3.47 and 3.00%, respectively) and the dried leaf curd had the least (1.29%). The CHO levels of the samples differed ($p<0.05$). The fresh pumpkin leaves had comparable ($p>0.05$) values (61.30-62.87%). However, the dried leaf curd had the highest CHO (76.99%) ($p<0.05$).

Table 3. β - *Carotene and Ascorbate composition of differently processed fluted pumpkin (Telfairia occidentalis) leaf on dry matter basis*

Nutrients	FLC	DLC	SHDPL	SDPL	FPL	LSD
β-Carotene (µg/g)	83.57^{a}	14.56^{d}	41.09^{c}	0.88^{e}	47.31^{b}	5.37
Ascorbate (mg /100g)	227^{a}	16.0^{c}	28.0^{b}	18.0^{c}	28.0^{b}	0.71

n= 3
*a-d: Values with the same letters are statistically similar ($p>0.05$) and those with different letters are different ($p<0.05$)
FLC - Fresh leaf curd
DLC - Dried leaf curd
SHDPL - Shade-dried fluted pumpkin leaf
SDPL - Sun-dried fluted pumpkin leaf
FPL - Fresh fluted pumpkin leaf

Table 3 presents the β - Carotene and Ascorbate composition of the five samples on dry matter basis. The β-carotene level of the samples differed. The values ranged from 0.88 to 83.57 µg/g. The sun-dried samples had significantly lower ($p<0.05$) β-carotene (0.88 µg/g) than the other samples ($p<0.05$). On the other hand, the fresh leaf curd had the highest ($p<0.05$) pro-vitamin A level. Shade-dried samples had higher β-carotene than the sun-dried (41.09 vs 0.88 µg/g). The ascorbate composition of the five samples differed. The dried leaf curd and the sun-dried sample had similar ascorbate (0.16 and 0.18 mg/100g) while the shade dried and fresh leaves had similar ($p>0.05$) levels (0.28 mg/100g respectively). On the other hand, the fresh leaf curd had significantly higher values ($p<0.05$) than the others.

4. Discussion

4.1. Proximate Composition

The higher protein level of the processed fluted pumpkin (*Telfairia occidentalis*) leaves (dried leaf curd, shade and sun-dried samples) than the fresh leaves was due to drying. Drying increased dry matter of which protein is one of them. This agrees with Aletor and Adeogun [18], who observed increase in protein of leaves when controlled drying was employed. A high level of protein (22.0%) in fluted pumpkin leaves was observed by Oguntona and Akinyele [19] on dry weight basis. The lower level of crude fat (ether extract) of the dried leaf curd than the other samples could be attributed to the processing. Though leaves are known to contain trace or no fat, [20] the shade

dried fluted pumpkin leaves had higher (8.98%) fat (on dry matter basis) than the level (6.5%) observed by Oguntona and Akinyele [19]. This could be attributed to the indirect solar drying which conserved the nutrient.

The low ash level of the processed leaves was comparable (3.49%, 1.21%, 2.99%, 2.20%) with values observed by Oguntona [20] in the baobab leaf (2.8%), Indian spinach (1.0%) and water leaf (1.32%) while the value for the fresh leaves (15.12%) is slightly higher with the value (11.0%) observed by Oguntona and Akinyele [19]. The low fibre content of the dried leaf curd might be due to the processing which involves sieving and discarding of residue. This might have led to loss of fibre [21]. The low fibre content in the processed leaves is an advantage for the formulation of low fibre infant formular to enable the infants and children consume more because of their small stomach capacity.

The lower ($p<0.05$) carbohydrate level of the fresh leaves than the processed and dried samples could be as a result of drying, which removed volatile moisture thereby concentrating the nutrient.

Overall, fresh leafy green vegetables have crude protein ranging from 1.5-1.7%, although some workers [18] have obtained a mean of 4.2% for seventeen of such vegetables. It was observed that when dried samples were used, the crude protein content ranges 15.0 to 30.0% though the means was usually around 20%.Very few reports exist on the protein constituents of the leafy vegetables. Schmidt [22] however, indicated that 75% of total nitrogen in most leafy vegetables in protein nitrogen. Many reports indicate that leafy vegetable protein is low in sulphur amino acids. FAO/WHO [23] depicted some of the essential amino acids in some of the leaves and the standard amino acid reference pattern.

4.2. β - *Carotene and Ascorbate Composition of the Leaf*

Pro-vitamin A (carotenoids) is affected by heat, cultivar and season of harvest. The lower value observed in the sun-dried sample could be as a result of the effect of sunrays on the carotenoids pigments. Sun-rays are known to destroy carotenoid contents of leaves. The lower levels of β-carotene for the dried leaf curd and the sun-dried samples could be attributed to the heat treatment. Freepatents [24] reported that β-carotene is not stable under sunlight and it is equally volatile.

The lower ascorbate level of the dried leaf curd and the sun-dried samples than the values observed by Oguntona and Akinyele [19] and Oguntona [20] could be due to processing (drying), which affected the ascorbate. Ascorbate is known to be unstable under heat. This shows that freshly consumed vegetables are better than processed ones in terms vitamin C retention. Heating destroyed ascorbate content of the dried leaf curd and the sun-dried samples. Paul and Southgate [25] also observed that cooking and handling increases loss of ascorbate.

As with other nutrients, many factors are known to influence the amount of vitamins in leafy vegetables. Cultivar and maturity are important factors while light can also sometimes be important. It is known that crops which mature during autum contain higher vitamin A precursor than those that mature in poorer light of winter. Also, the richest vegetable sources of thiamin include leafy green vegetables. It is known that this vitamin is retained at high levels in the leaves before being transferred to the seed or root at maturity [26 - 28]. The studies showed that green vegetables contain small quantity of riboflavin though niacin and folate can be present in reasonable amounts. Green leafy vegetables are good sources of vitamin C and this component of Nigerian green leafy vegetable has received considerable attention from Nigeria scientists over the years [26].

5. Conclusion

The results of this study showed that sun and shade-dried fluted pumpkin leaf and the leaf curd have promising nutrient potentials. The fresh leaf curd and fresh curd and fresh fluted pumpkin leaf are good sources of *β*-carotene, ascorbate, iron, copper, zinc and calcium. On dry matter basis, the dry leaves and the leaf curd are good sources of protein.

Feeding rats with rat chow supplemented with the processed leaves improved both serum and liver *β*-carotene, ascorbate, ferritin, iron, copper, zinc and calcium as well as the haemoglobin concentration.

The processing of fluted pumpkin (*T. occidentalis*) leaves into leaf curd reduced bulk and increased micronutrient density of the vegetable thereby improving its nutritional quality. The rich nutrient potentials of the curd could be employed in infant food formulation.

Recommendations

Based on the results of the study, the following recommendations were made:

(1) Dietitians, nutritionists should use the information from this study to counsel families, mothers and care-givers on the consumptions of green leafy vegetables both in season and in scarcity by processing into leaf curd or shade- drying.

(2) Fluted pumpkin leaf curd should be used as an ingredient in the formulation of complementary food to increase nutrient density.

(3) Shade-dried and leaf curd samples should be produced from popular and lesser known seasonal green leafy vegetables.

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