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**Research article**

# EFFECTS OF TREATMENT METHODS ON THE PROXIMATE COMPOSITION AND THE ANTI-NUTRITIONAL COMPONENTS OF NORMAL AND LATE HARVEST TRIFOLIATE YAM (*Dioscorea dumetorum*)

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## ABSTRACT

Flours of trifoliate yam were prepared from two representatives of the sample, the normal and late harvest. The normal harvest was divided into two portions; normal uncooked oven dried (NUOD) and normal cooked oven dried (NCOD) while the late harvest was divided into three portions; Late uncooked oven dried, (LUOD), Late steeped oven dried, (LSOD) and late cooked oven dried (LCOD). The treatment effects on the chemical composition and anti-nutritional components of the flour samples were analyzed. The result revealed that LSOD had highest moisture content (8·10%) whereas, LUOD was lowest (6·38%). NUOD had the highest ash content (7·80%), and LCOD was lowest (5·70%). LUOD was highest in fibre content (3·96%), while LCOD (1·23%) being the lowest. NCOD was highest in fat content (0·80%) whereas LCOD was lowest (0·32%).

LUOD had highest protein content (4·20%) whereas NCOD had the lowest (2·10%). LCOD was with highest carbohydrate content (82·25%) and NUOD was lowest with (77·24%). These results were significantly ($p<0·05$) different. The anti-nutrient result showed, LUOD was highest in tannin (8·40mg/100g), phytate (3·85mg/100g) and oxalate (280·80mg/100g), whereas, NCOD was with lowest tannin (0·38mg/100g) and oxalate (0·11mg/100g) contents. NUOD had lowest phytate content (0·21mg/100g). These results indicated that the treatment methods significantly ($p>0·05$) reduced the anti-nutritional contents of normal and late harvest trifoliate yam, hence, will improve their utilization. **Copyright © WJAFST, all rights reserved.**

**Key words:** anti-nutritional, harvest, proximate**,** treatment**,** trifoliate yam

## INTRODUCTION

Trifoliate yam (*Dioscorea dumentorum*) is one of the numerous species of yam (*Dioscorea*) in the family of *dioscpreacea*. It is also known as African bitter yam, cluster yam because usually its tubers are bunched, and three - leaved yam. In Nigeria, the Igbos call it ‘‘*Ona*’’ and the Yorubas call it ‘‘*Esuri*’’.

Trifoliate yam is a good source of carbohydrate (70·35 %) and possesses relatively high protein content (9·85%) when compared with other *Dioscorea* species (Ezeocha and Oti, 2013).

The trifoliate yam is usually harvested within six months of cultivation. Within this period of maturity and harvest, the tubers are cooked and usually eaten with palm oil preparation in the eastern part of Nigeria. Its utilization in human diet is restricted when harvested late (one year and above) because of its bitter taste, hard-to-cook property and believed toxicity to human. As a result, late harvested trifoliate yams are unacceptable by consumers and therefore underutilized.

Generally, the nutritive and anti-nutritional properties of trifoliate yam are documented (Abiodun and Akinoso, 2014), but effect of harvesting periods and pre-treatment methods on the functional properties had not been widely studied. This could probably be due to lack of information on the usefulness and importance of the flours for functional food products. The lack of information could have led to the under utilization of the raw material. Therefore, the objectives of this study are:

1. To produce flour samples from normal (6months) and late harvest trifoliate yam after the treatment of steeping and cooking.

2. To determine and compare the anti-nutritional content of the different flour samples.

Studying the properties of trifoliate yam flours as affected by harvesting periods and pre-treatment methods will provide a wide range of information on its varying characteristics which could be useful to food processors. Being a high yielding and cheaper crop, it could serve as a raw material for food formulation.

## MATERIALS AND METHODS

The normal and late harvests of trifoliate yam for this work were sourced from Ngwu – Uzuakoli in Bende Local Government Area of Abia State, Nigeria.

**Plate 1:** Normal harvest peeled and oven-dried trifoliate yam chips (NUOD)

**Plate 2:** Normal harvest cooked, peeled and oven-dried trifoliate yam chips (NCOD)

**Plate 3:** Late harvest peeled, sliced, and oven-dried trifoliate yam chips (LUOD)

**Plate 4:** Late harvest peeled, sliced, steeped for 24hrs and oven-dried trifoliate yam chips (LSOD)

**Plate 5:** Late harvest cooked, peeled and oven-dried trifoliate yam chips (LCOD)

## Sample preparation:

### Preparation of Flour Samples of Normal Harvested Trifoliate yam Tubers

The Raw Normal Harvested trifoliate yam was cleaned, washed, boiled for 1h, sliced with kitchen knife using to a thickness of 0·5cm and then oven dried at 80°C. The obtained dry chips were pulverized using a CORNA LANDER and CIA.S.AK Manual grinder and sieved using SETHI Standard Test Sieve BSS 60 AS PER IS: 460. The flour obtained was packaged in a dry container and labelled "Normal Cooked and Oven Dried" (NCOD).

A sample of uncooked Normal Harvested trifoliate yam was prepared as in "NCOD" above with cooking being the only difference. The flour obtained was packaged in a dry container and labelled "Normal Uncooked and Oven Dried" (NUOD).

### Preparation of Flour Sample from Late Harvested Trifoliate yam Tubers

Some of late harvested Trifoliate yam tubers were cleaned, peeled and washed before cutting into chips of about 0·5cm thickness using kitchen knife. The chips were then soaked in clean water for about 24h after which they were oven - dried at a temperature of 80°C. They were next pulverized and sieved using SETHI Standard Test Sieve, BSS 60 AS PER IS: 460. The flour obtained was packaged in a dry container, labelled "LSOD" (Fig 1) and stored for subsequent use. This formed the first treatment sample from the late harvest. Another set of tubers from the late harvest were cleaned, washed and boiled in clean water for about an hour. The cooked tubers when cooled were peeled and sliced into 0·5cm thickness. The chips were oven dried at temperature of 80°C, pulverized and sieved using SETHI Standard Test Sieve, BSS 60 AS PER IS: 460. The flour obtained was packaged in a dry container, labelled "LCOD" (Fig 1) and stored for subsequent use. This formed the second treatment sample from the late harvest. A third set of tubers from the late harvest were cleaned, washed, peeled, sliced (0·5cm thickness) and dried in oven at about 80°C. This was later pulverized and sieved using SETHI Standard Test Sieve, BSS 60 AS PER IS: 460. The flour obtained was packaged, labelled "LUOD" (Fig 1) and stored for subsequent use. This formed the third sample from the late harvest.

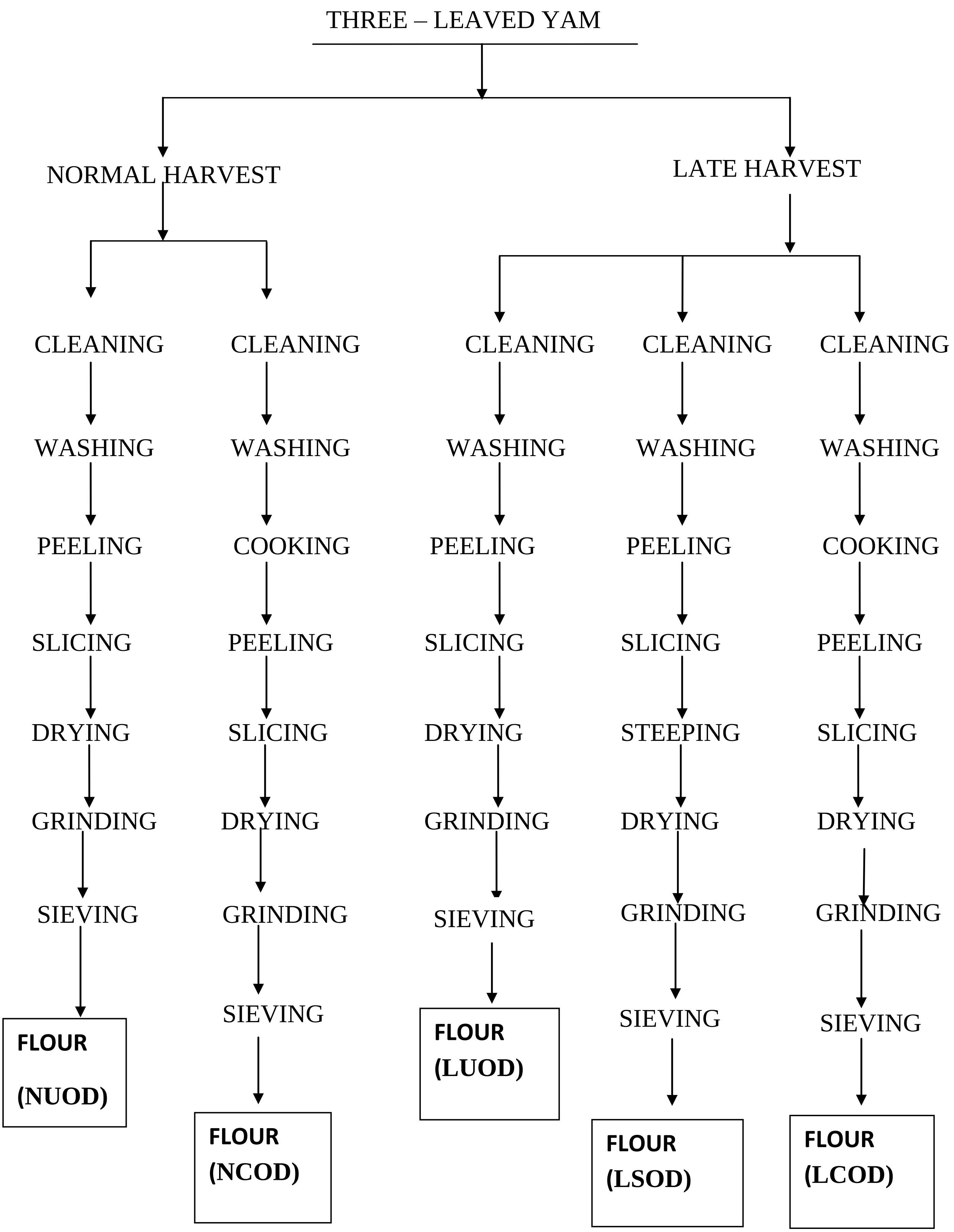
THREE – LEAVED YAM
NORMAL HARVEST
LATE HARVEST
CLEANING
WASHING
PEELING
SLICING
DRYING
GRINDING
SIEVING
FLOUR (NUOD)
CLEANING
WASHING
COOKING
PEELING
SLICING
DRYING
GRINDING
SIEVING
FLOUR (NCOD)
CLEANING
WASHING
PEELING
SLICING
DRYING
GRINDING
SIEVING
FLOUR (LUOD)
CLEANING
WASHING
PEELING
SLICING
STEEPING
DRYING
GRINDING
SIEVING
FLOUR (LSOD)
CLEANING
WASHING
COOKING
PEELING
SLICING
DRYING
GRINDING
SIEVING
FLOUR (LCOD)

**Figure 1:** Flow diagram for the production of trifoliate yam flour samples

**KEY:**
**NUOD –** Normal harvest Uncooked Oven-Dried (Raw Normal Harvest Sample)
**NCOD –** Normal harvest Cooked Oven-Dried
**LUOD –** Late harvest Uncooked Oven-Dried (Raw Late Harvest Sample)
**LSOD –** Late harvest Steeped Oven-Dried
**LCOD –** Late harvest Cooked Oven-Dried

## Determination of Proximate Composition of the Trifoliate Yam Flours

The proximate composition of the five (5) flour samples of trifoliate yam were determined according to AOAC (2000) methods. All the analyses were done in triplicate and the results calculated as means of the three (3) analyses.

## Determination of the Anti-Nutritional Components of Trifoliate Yam Flour

The three (3) major anti-nutritional components analysed for in the flour samples were; Oxalate, Tannin, and Phytate.

## Determination of oxalate

The oxalate was determined by the titration method as described by Osagie (1998). This method of determination involves three (3) major steps: digestion, oxalate precipitation and permanganate titration.
In digestion, two grams (2g) of the sample was suspended in 190ml of distilled water in a 250ml volumetric flask, and 10ml of 6MHCl was added and the suspension digested at 100°C for 1hr. Then the hot digest was cooled and then made up to 250ml mark before filtration. Duplicate portions of 125ml of the filtrate were measured into beakers and four drops of methyl red indicator were added. This was followed by the addition of $NH_4OH$ solution (drop-wise) until the test solution changed from salmon pink colour to a faint yellow colour (pH4-4.5). Each portion was then heated to 90°C, cooled and filtered to remove the precipitate which contained ferrous ion. The filtrate was again heated 90°C and 10ml of 5% $CaCL_2$ solution was added while being stirred constantly. After heating, it was cooled and left overnight at 25°C. The solution was then centrifuged at 2500rpm for 5mins. The supernatant was decanted and the precipitate completely dissolved in 10ml of 20% (v/v) $H_2SO_4$ solution.

At this point, the total filtrate resulting from the digestion of 2g of the flour sample was made up to 300ml Aliquots (125ml) of the filtrate was heated until near - boiling and then titrated against 0.05M standardized KMNO4 solution to a faint pin colour which persisted for 30s. The calcium oxalate content was calculated using the formula below

$$\frac{T \times (v_{me})\,(Df) \times 10^5 \quad (\text{mg}/100)}{(ME) \times mf}$$

Where T is the titre of $KMNO_4$(ml), $V_{me}$ is the mass equivalent (i.e 1ml of 0.05m $KMNO_4$ solution is equivalent to 0.00225g anhydrous oxalic acid). Df is the dilution factor $v_t/A$ (2.4), $v_t$ is the total volume of titrate (300ml) and A is the aliquot used (125ml), ME is the molar equivalent of $KMNO_4$ in oxalate and mf is the mass of sample used.

## Determination of tannin

The Follins Dennis titration method as described by Pearson (1974) was used. To 20g of the powdered sample was added 100ml of petroleum ether in a conical flask and covered for 24hrs. The sample was then filtered and allowed to stand for 15mins, allowing petroleum ether to evaporate. It was then re-extracted by soaking in 100ml of 10% acetic acid in ethanol for 4hrs. The sample was then filtered and the filtrate was collected.

Then 25ml of $NH_4OH$ was added to the filtrate to precipitate the alkaloids. The alkaloids were heated with an electric hot plate to remove some of the $NH_4OH$ remaining in the solution. The remaining volume was measured (33ml), 5ml of this was taken and 20ml of ethanol was added to it and the resultant solution was titrated with 0.1M NaOH using phenolphthalein as indicator until pink red end point was reached.

Tannin content was then calculated as % ($C_1V_1 = C_2V_2$) molarity.

## Where,

$C_1$ = conc. of tannic acid

$C_2$ = conc. of base = 0.1

$V_1$ = volume of tannic = 5ml

$V_2$ = volume of base = titre

Therefore, $C_1 = C_2V_2/V_1$

% of tannic acid content = $C_1 \times 100$/weight of sample analysed

## Phytate determination

The Phytate contents were determined using the method of Lucas and Markakes (1975). In this method 0.2g of each of the samples was weighed into different 250ml conical flasks. Each sample was soaked in 100ml of 2% concentrated HCl for 3h. The samples were then filtered. Fifty millilitres (50ml) of each filtrate was placed in 250ml beaker and 100ml distilled water added to each sample. Ten millilitres (10ml) of 0.3% ammonium thiocyanate solution was added as indicator and titrated with standard iron (iii) chloride solution which contained 0.00195g iron per ml. The percentage phytic acid was calculated using the formula:

$$\text{Phytic acid (\%)} = \frac{\text{Titre value} \times 0{\cdot}00195 \times 1{\cdot}19 \times 100}{2}$$

## RESULTS AND DISCUSSION

### Proximate analysis of Trifoliate Yam (*Dioscorea dumetorum*)

The result of the proximate analysis of normal and late harvest trifoliate yam flour samples prepared by subjecting the samples to different pre-treatment methods prior analysis is presented in table 1.

### Moisture content

The moisture content of the Normal harvest Uncooked and Oven-Dried (NUOD) sample was 7·36±0·27% which is lower than that of Normal harvest, Cooked and Oven-Dried (NCOD) sample which had 7·63±0·05% moisture. For the Late harvest samples, the uncooked and oven-dried sample (LUOD) had the lowest moisture content of 6·38±0·02% while the steeped sample (LSOD) had the highest moisture content 8·10±0·05% followed by the cooked sample (LCOD) which had 7·48±0·10% moisture. The moisture content of the normal and late harvest trifoliate yam flour samples were significantly ($p<0·05$) different. The highest moisture content observed in the cooked and steeped samples could possibly be as a result of the moisture absorbed during cooking and steeping processes. These values were slightly higher than the 5·26 - 7·57% reported by Udensi *et al.* (2008). The moisture levels were however within the acceptable limit of not more than 10% for long term storage of flour.

**Table 1:** Mean values ± Standard Deviation of the Proximate Composition of Trifoliate yam (*D. dumetorum*).

| SAMPLE | MOISTURE CONTENT (%) | ASH CONTENT (%) | FIBRE CONTENT (%) | FAT CONTENT (%) | PROTEIN CONTENT (%) | CHO CONTENT (%) |
|---|---|---|---|---|---|---|
| NUOD | 7·360±0·27$^{d}$ | 7·800±0·01$^{a}$ | 2·90±0·10$^{b}$ | 0·80±0·10$^{a}$ | 3·9±0·10$^{b}$ | 77·24±0·04$^{e}$ |
| NCOD | 7·630±0·05$^{b}$ | 7·620±0·02$^{b}$ | 3·00±0·10$^{b}$ | 0·75±0·03$^{a}$ | 2·1±0·10$^{e}$ | 78·90±0·10$^{d}$ |
| LUOD | 6·380±0·02$^{e}$ | 6·513±0·02$^{c}$ | 3·96±0·01$^{a}$ | 0·60±0·09$^{b}$ | 4·2±0·10$^{a}$ | 79·15±0·50$^{c}$ |
| LSOD | 8·100±0·05$^{a}$ | 5·800±0·10$^{d}$ | 2·62±0·02$^{c}$ | 0·40±0·10$^{c}$ | 3·7±0·13$^{c}$ | 79·43±0·01$^{b}$ |
| LCOD | 7·480±0·10$^{c}$ | 5·700±0·10$^{d}$ | 1·23±0·06$^{d}$ | 0·32±0·02$^{c}$ | 3·0±0·10$^{d}$ | 82·25±0·05$^{a}$ |

$^{abc}$Means ±Standard deviation with different superscript within the same column are significantly different ($p\geq0·05$)

**KEY:**
**NUOD –** Normal harvest Uncooked Oven-Dried (Raw Normal Harvest Sample)
**NCOD –** Normal harvest Cooked Oven-Dried
**LUOD –** Late harvest Uncooked Oven-Dried (Raw Late Harvest Sample)
**LSOD –** Late harvest Steeped Oven-Dried
**LCOD –** Late harvest Cooked Oven-Dried

## Ash content

Ash content of the samples were significantly ($p < 0·05$) different and ranged from 5·70±0·10% - 7·80±0·01%. The Raw/ Uncooked sample of the Normal harvest (NUOD) had ash content of 7·80±0·01% which was the highest observed in all the samples. NCOD, LUOD, LSOD and LCOD had ash contents of 7·62±0·02%, 6·51±0·02%, 5·80±0·10% and 5·70±0·10% respectively. The values were comparable to literature values as reported by Shanthakumari *et al*. (2008). The decrease observed in the ash content of the cooked samples of both normal and late harvest could be due to leaching of the minerals in water during cooking.

## Fibre content

Crude fibre content noted was in line with the reports of earlier research by Alinnor and Akalezi (2010). NUOD sample had a fibre content of 2·9±0·10%, NCOD, LUOD, LSOD and LCOD had 3·00±0·10%, 3·16±0·01%, 2·62±0·02% and 1·233±0·06% fibre content respectively. The fibre content of all the flour samples were significantly ($p < 0·05$) different. There was an observed decrease in fibre content of the steeped and cooked samples which was due to leaching of their fibre content while the untreated samples had higher fibre content. The LUOD sample had the highest fibre content (3·96%), while the LCOD sample had the least fibre content (1·23%).

## Fat content

All the samples had low fat contents below 1·0% (Table 4·1) similar to values found by Agbor-Egbe and Treche (1995) on trifoliate yams (0·10 - 0·92%). NUOD flour sample was observed in this study to have the highest fat level of 0·80±0·10% while LUOD flour samples had the lowest (0·32±0·02%). There were significant ($p < 0·05$) differences in fat content amongst the studied flour samples. NCOD, LUOD and LSOD samples had fat contents of 0·75±0·05%, 0·60±0·09% and 0·40±0·10% respectively. The decrease in the fat content of the cooked normal and late harvest samples indicated the reductive effect of temperature rise on fat which led to leaching of the fat content of the cooked samples into the water.

## Protein content

In all the samples analysed, the protein content recorded for the flour samples were generally lower than what has been previously reported by Agbor-Egbe and Treche (1995) and Shanthakumari *et al*. (2008). The flour samples, NUOD, NCOD, LUOD, LSOD and LCOD had 3·90±0·10%, 2·10±0·10%, 4·20±0·10%, 3·65±0·13% and 3·00±0·10% protein content respectively. The protein contents of the samples were significantly ($p < 0·05$) different. In all the samples analysed, it was observed that the protein content of the cooked samples were lower than those of the steeped samples. This obviously showed that protein is denatured by heat treatment, pre-cooking improves the functional properties of the flour and therefore makes the flour important in food formulation (*Bhandari et al.,* 2003). Cooking denatures protein to make it easier for enzymes to digest them. The increase in the protein content of LSOD among the late harvest samples could be as a result of enzymes production of the sample (Bhandari, *et al.*, 2003).

## Carbohydrate content

The carbohydrate content of the flour samples were significantly ($p < 0{\cdot}05$) different. The samples carbohydrate content were; NUOD 77·24±0·03%, NCOD 78·90±0·10%, LUOD 79·15±0·05%, LSOD 79·43±0·01% and LCOD 82·25±0·05%. These values are comparable to Udensi *et al*. (2008). The result showed that cooking increased the carbohydrate content of the trifoliate yam. The increased carbohydrate could be as a result of reduction in some of the nutrients. The high carbohydrate and energy value of flour samples recorded in this study make them reliable food security crops.

## Anti-nutritional components of the trifoliate yam:

## Tannins content

The results of the anti-nutritional content of the trifoliate yam flour samples on table 2 showed that there was no significant ($p > 0{\cdot}05$) difference in the tannin content of the normal harvest flour samples (NUOD and NCOD), but significantly different ($p < 0{\cdot}05$) from the late harvest. The tannin content of the late harvest flour samples (LUOD, LSOD and LCOD) were significantly ($p < 0{\cdot}05$) different from each other and higher than those of the normal trifoliate yam flours.
These could be responsible for some of the properties that cause consumer rejection and underutilization of the late harvest trifoliate yam.

The lower values observed in the treated samples, NCOD in the normal harvest and LSOD and LCOD in the late harvest showed the effectiveness of steeping and cooking treatments in the reduction of anti-nutritional content of the samples.

This is in support of the findings of Soetan and Oyewole (2009) which stated that different processing treatments like soaking, cooking, etc, can reduce the toxic effects of most anti-nutritional factors present in the plant foods.

**Table 2:** Mean ± Standard Deviation Values of the Anti-nutritional Content of Trifoliate Yam (*D. dumetorum*).

| SAMPLES | TANNINS mg/100g | PHYTATE mg/100g | OXALATE mg/100g |
|---|---|---|---|
| **NUOD** | 0·41±0·02[d] | 0·21±0·01[c] | 0·16±0·01[d] |
| **NCOD** | 0·38±0·01[d] | 1·64±0·03[d] | 0·11±0·01[d] |
| **LUOD** | 8·40±0·10[a] | 3·85±0·05[a] | 280·80±0·01[a] |
| **LSOD** | 3·90±0·10[c] | 1·97±0·01[c] | 86·75±0·05[c] |
| **LCOD** | 5·46±0·36[b] | 2·18±0·02[b] | 105·84±0·02[b] |

[abc]Means ±Standard deviation with different superscript within the same column are significantly different ($p \geq 0{\cdot}05$)

**KEY:**

**NUOD –** Normal harvest Uncooked Oven-Dried (Raw Normal Sample)

**NCOD –** Normal harvest Cooked Oven-Dried

**LUOD –** Late harvest Uncooked Oven-Dried (Raw Late Sample)

**LSOD –** Late harvest Steeped Oven-Dried

**LCOD –** Late harvest Cooked Oven-Dried

## Phytate content

The result of the phytate content on table 2 showed that there were significant ($p < 0{\cdot}05$) differences among all the samples.

The normal uncooked oven-dried (NUOD) sample had the least phytate content (0·216) while the late harvest uncooked oven-dried (LUOD) sample had the highest phytate content (3·85%). Steeping and cooking significantly ($p<0{\cdot}05$) reduced the phytate content of all the late harvest flour samples (LUOD, LSOD and LCOD) which were higher than the phytate content of normal harvest samples (NUOD and NCOD). This could be responsible for some of the factors that cause rejection of late harvest trifoliate yams. Phytic acid combines with some essential elements such as irons, calcium, zinc and phosphorus to form insoluble salts and therefore reduce the bioavailability of these elements (Umaru *et al*., 2006). It is therefore necessary that these plant foods are properly treated to reduce their anti-nutrients in order to make the nutrients bio-available for the cells to utilize them.

## Oxalate content

The result of the oxalate content on table 2 showed that the oxalate of all the late harvest samples of trifoliate yam flour were higher than the normal harvest flour. The normal harvest had oxalate content of 1·16 and 0·11mg/100g while the late harvest had oxalate values ranging from 86·75 to 280·80mg/100g. The late uncooked oven dried sample had the highest oxalate content (280mg/100g) followed by the LCOD (105·84mg/100g) and LSOD (86·75mg/100g). There was no significant ($p > 0{\cdot}05$) difference in the oxalate content of the normal harvest samples (NUOD and NCOD), while there were significant ($p < 0{\cdot}05$) differences in oxalate contents of all the late harvest samples. This high oxalate content in the late harvest flours may have contributed to some of the rejection factors in late harvest trifoliate yam.

## CONCLUSION

The results of this study showed that both normal and late harvest trifoliate yam flours contain some nutrients as well as anti-nutritional factors. The anti-nutritional factors such as tannin, phytate, and oxalate were found to be higher in all the late harvest samples than the normal harvest. The steeping and cooking treatment methods were able to reduce the anti-nutritional factors in the late harvest trifoliate yam flours to reasonable levels, though the steeping method was more effective in reducing the anti-nutrients than the cooking treatment. However these results have shown that the anti-nutritional factors in the late harvest trifoliate yam could be reduced to reasonable levels by the steeping and cooking treatments. This could now make it safe for human consumption and more utilized for industrial productions such as livestock feeds and flours for baking purposes.

## RECOMMENDATION

Based on the findings of this research, the steeping and cooking treatments separately reduced the anti-nutritional factors in the late harvest significantly ($p < 0{\cdot}05$). Therefore both treatment methods should be used together to further reduce the anti-nutritional factors in the late harvest trifoliate yam. This could make it safer for human consumption, more accepted by the consumers and better utilized for industrial purposes. Also, further research work be conducted to test the effect of these two treatments or more applied together on the anti-nutritional factors of late harvest trifoliate yam.

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