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Nutrient contents and thermal degradation of vitamins in organically grown fluted pumpkin (*Telfairia occidentalis*) leaves

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Abstract: The nutrient contents of a widely-consumed leafy vegetable produce – *Telfairia occidentalis* - using poultry manure (PM) and mineral fertilizer (Nitrogen, phosphorus and potassium-NPK) application were evaluated for comparison. PM at four levels (0, 5, 10 and 15 tonnes) and a standard rate of 90kg NPK per hectare was applied. Leaves were harvested for immediate analyses at 15 weeks after planting to determine the proximate composition, elemental nutrient composition, water-soluble vitamins and anti-nutrient contents. Kinetics of vitamin degradation during drying of leaves at 50, 55 and 60°C and durations for 30 to 180 minutes was investigated. Data obtained showed that proximate composition was significantly affected by treatments ($p<0.05$) except crude protein. The values of elemental nutrient analysed were significantly different ($p<0.05$), except for potassium (K). Significant differences ($p<0.05$) due to fertilizer application observed for the water soluble vitamins except thiamine content. No significant difference ($p>0.05$) was observed in the anti-nutrient contents of the leaves. The percentage loss of the vitamins investigated revealed similar trends after drying for about 180 minutes with vitamin C having the highest values (29.35 to 37.07%); followed by thiamine (26.67 to 32.61%); and riboflavin (25.65 to 31.30%). Regression model was developed for retention of vitamins as a function of tonnage of PM, drying temperature and time with high values of R^2 (0.901-0.951).

Keywords: Fluted pumpkin, poultry manure, nutrient contents, drying, degradation, kinetics

Introduction

Organic agriculture represents a system of production which is looking for harmony between the environment and agriculture productions (Borguini *et al*., 2003). However, for these objectives to be realized, it will be necessary to reduce the use of fertilizers and chemical pesticides because they can cause problems both at ecological and human health level, due to human over exposure to synthetic molecules, in particular following indiscriminate use (Penteado, 2000). Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. In general, the public perceives organic foods as being healthier and safer than those produced through conventional practices. However, controversy remains regarding whether or not organic foods have a nutritional and/or sensory advantage when compared to their conventionally produced counterparts. Advocates for organic produce claim it contains fewer harmful chemicals, is better for the environment and may be more nutritious (Mitchell and Chassy, 2008).

Fluted pumpkin (*Telfairia occidentalis* Hook .f.) belonging to the family Cucurbitaceae, is a tropical vine grown in West Africa as a leafy vegetable and for its edible seeds. It is a leafy vegetable that has been widely accepted as a dietary constituent among peasants in Nigeria (Akwaowo *et al*., 2000). The plant produces luxuriant edible green leaves, which are rich in iron and water soluble vitamins such as vitamin C, riboflavin and thiamine. The tender leaves are consumed by man as vegetables as well as by livestock (sheep, pigs and goats) as forage, while the young seeds are eaten as human food (Akorodu, 1990; Badifu and Ogunsua, 1991; Akwaowo *et al*., 2000). Vegetable products are of importance in human nutrition and they will continue to remain as the primary source of energy, lipids, and carbohydrates, including fibers, minerals and vitamins in developing countries (Oyolu, 1980; Lima *et al*., 2009). The leaves and edible shoots of fluted pumpkin together contain 85% moisture, while the dry portion of what is usually consumed, contains 11% crude protein, 25% carbohydrate, 3.0% fat, 0.58% phosphorus, 4.32%

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potassium, 0.56% magnesium, 0.47% calcium and 700ppm iron (Oyolu,1980). According to Akwaowo *et al.* (2000), the older leaves of fluted pumpkin were higher in percentage crude protein, crude fat, ash and crude fibre while the younger leaves were higher in moisture content and carbohydrate. The older leaves contain 39.4% crude protein in comparison to 22.4% for younger leaves. The plant also contains considerable amount of anti-nutrients like phytic acid, tannin, oxalic acids, hydrocyanic acid and saponins (Ladeji *et al.*, 1995; Akwaowo *et al.*, 2000; Ajibade *et al.*, 2006). The leaves are also rich in iron, thus used to cure anaemia (Ajibade *et al.,* 2006). These anti-nutrients are widely distributed in some vegetable crops with notable effects on other nutrients especially reducing bio-availability of some metals like calcium, iron etc (Okoro, 1989; Hurrel *et al.*, 1992).

Recently, there has been an increasing demand for organic fruits and vegetables due to human health benefits (Sacilik *et al.*, 2006). A number of studies have identified the reasons behind the considerable increases in consumer demand for organic foods, although the relative importance of factors may vary from country to country (Bourn and Prescott, 2002). Frequently, surveys report pesticide residues in food (i.e., concerns for own health) to be more important in the decision to purchase organic foods products than the concern for the environment as a whole, although this factor is more important in some countries (Bourn and Prescott, 2002). However, the nutritional quality of foods grown by the organic and conventional methods is a subject of much controversy. Organic advocates claim that organically grown foods are nutritionally superior because such foods contain higher levels of vitamins, minerals and amino acids. On the other hand, the mainstream scientific community disputes these claims, arguing instead that nutritional differences do not exist. "Plant can not differentiate between organic and chemical fertilizers" is an often quoted statement in support of this latter (Diver, 2002).

Organic farming is likely to receive a major boost in many countries and most probably worldwide since consumers have lost some trust in food derived from conventional production due to some crises such as mad cow disease, foot-and-mouth epidemic, and also due to concerns regarding use of pesticides in farming and antibiotics in livestock feed (Siderer *et al.*, 2005). Adequate consumption of leafy vegetables has been reported as an important means of fighting hunger and malnutrition, ensuring food security and generating income for farmers. Despite the widespread cultivation and consumption of *Telfairia occidentalis* in the diets of many Africans, farmers are facing lots of problems concerning its production. Yield and quality of the leaves and seeds realized by farmers are usually lower than what is being reported under experimental conditions (Fashina *et al.,* 2002). In addition, improved soil nutrients could also improve the quality of these vegetables in terms of minerals, vitamins and protein content. Research efforts are, therefore, required to formulate and recommend fertilizer requirement for sustainable production of this vegetable. Hence, the objective of this study is to evaluate the effect of organic fertilizer (poultry manure) application on the nutritional composition of fluted pumpkin (*Telfairia occidentalis*) leaves and to evaluate the intensity of thermal degradation of water soluble vitamins on the leaves as influenced by drying temperatures.

Materials and Methods

Source of materials and sample preparation

Fluted pumpkin seeds were sown in December 2007 in the Fadama farm of the University of Agriculture, Abeokuta, Nigeria. The seeds were planted on a field trial randomized block with three replicates of five treatments. The treatments used were poultry manure at four levels (0, 5, 10 and 15 tonnes per hectare) of application and a standard rate of 90kg NPK (nitrogen, phosphorus and potassium fertilizer) per hectare. Leaves were harvested for immediate analyses at 15 weeks after planting. The vegetable stalks were removed and the leaves rinsed with clean water before dividing into two portions for chemical analysis and drying experiment.

Chemical analysis

Proximate composition for nutrients of the fresh samples of OGFP and NPK leaves were determined according to the official methods of Analysis of AOAC (2000). The moisture content of the clean samples was determined by drying known weight of samples to a constant weight at 105^{o}C. Protein content was calculated from the kjeldahl nitrogen using the conversion factor of 6.25. Lipid content was estimated by extracting known weight of sample with petroleum ether (BP 60^{o}C) using a soxhlet apparatus. Ash content was determined by ignition in a muffle furnace for 4hr at 525^{o}C. Fibre content was estimated from the loss in weight of the crucible and its content on ignition. Carbohydrate was determined when the sum of the percentages of moisture, ash, crude protein, ether extracts and crude fibre were subtracted from 100. Mineral elements were estimated using the AOAC (2000) method. The Atomic absorption spectrophotometer was used to determine calcium, magnesium, potassium, zinc, copper, sodium and iron contents of the samples. Phosphorus (P) was measured by converting phosphate into phosphorus molybdate blue pigment and assayed at 700nm.

Riboflavin and thiamine were determined using a spectrophotometeric method as described by Onwuka (2005) while the 2, 6-dichloro-indophenol visual titration method as described by Pearson's (1991) was used for vitamin C determination. The phytate content was analysed according to the method described by Oberlease *et al*. (1962), while the Folin-Denis spectrophotometric method as described by Pearson (1991) was used for tannin determination. The oxalate content was determined using the method described by Ukpabi and Ejidoh (1989) while the cyanide content was determined by the method described by AOAC (2000).

Drying experiments

The fresh samples of organically grown fluted pumpkin (OGFP) and NPK treated leaves were dried using a convective hot air dryer (Gallenkamp S.G 94/04/609, UK) at 50, 55 and 60^{o}C at a speed of 1.5m/s (Sobukola and Dairo, 2007). The drying system was run for about 40 minutes to obtain a stable condition before placing samples in the chamber in thin layer. Small portions were taken out of the sample placed in the dryer at interval of 30 minutes and analysed for the water soluble vitamins (vitamin C, thiamine and riboflavin).

Kinetic modeling of nutrient loss

The change in quality indices (*dc*), of a foodstuff, either positively or negatively, at a constant temperature, T (expressed in absolute) over a period of time, dt can be described by a relationship (Labuza and Kanman, 1983):

$$\frac{dc}{dt} = \pm k(T).C^n \quad (1)$$

where k is the specific rate constant for change; T is absolute temperature (K) and n is order of reaction. Hence, the integral of the differential form of Equation (1) can be used directly to generate nth-order of reactions.

On the basis of first-order reaction for the degradation changes of ascorbic acid in blanched vegetables as proposed by Kincal and Gray (1987):

$$\ln\left(\frac{C_a}{C_{ao}}\right) = kt \quad (2)$$

where: C_a is the concentration of process time, t; C_{ao} is the initial concentration (at t = o) and k is the degradation rate constant.

Thus, Equation (2) allows the logarithmic plots of experimental values of C_a/C_{ao} against process time, t in which the straight lines obtained are indications of the validity of the first-order reaction kinetics for the food system under consideration. The Equations (1) and (2) were adopted for the determination of degradation kinetics of water soluble vitamins in the OGFP and NPK leaves during drying as adopted earlier for some Nigerian leafy vegetables (Solanke and Awonorin, 2002).

Consideration for temperature potential

According to Labuza and Riboh (1982), the intensity of heat on degradation of most nutrients in foods can be determined using the Arrhenius relationship, such that temperature dependence of k closely follows the equation:

$$k = k_o e^{-E_a/RT} \quad (3)$$

where: ko is pre-exponential constant; E_a is the activation energy of the reaction; T is the absolute temperature of the medium; and R is the universal gas constant.
Equations (1) and (3) can be combined to obtain:

$$dc/dt = k_o C^n \exp(-E_a/RT) \quad (4)$$

hence,

$$\ln\left(dc/dt\right) = \ln k_o + n \log C - E_a/RT \quad (5)$$

The parameters E_a and k_o in Equations (3) or (5) are of fundamental interest since they both represent the energy and factor levels associated with a reference absolute temperature for activation reaction, respectively. Both values were obtained from the plots of k versus l/T values using semi log coordinate.

$$Slope = E_a/2.303R \quad (6)$$

$$\text{Intercept} = \log k_o \quad (7)$$

Statistical analysis

All data obtained were subjected to analysis of variance (ANOVA) using SPSS statistical package. Means were separated with Duncan Multiple Range Test (DMRT) to establish if there is any significant difference between samples. Regression modeling of the percentage vitamin retention was carried out using equation 8:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (8)$$

where Y is vitamin retained (%), X_1, X_2 and X_3 are the level of PM applied (tonnes), drying temperature (^oC) and drying time (minutes) and ε is error term.

Results and Discussion

The results of the proximate analysis of the freshly harvested OGFP and NPK grown leaves are presented in Table 1. The moisture content ranged between 81.09 and 84.83% with the highest value observed in leaves grown with inorganic fertilizer (NPK 90kg/ha). The crude protein values ranged between 31.68 and 32.88% with the highest value observed in leaves grown with inorganic fertilizer while lower values were observed in OGFP leaves, however no significant differences were observed. The values obtained for crude fat, carbohydrate, ash content and crude fibre ranged from 8.19 to 10.75%, 34.17 to 44.61%, 7.92 to 10.25% and 7.74 to 12.18%, respectively. The crude fat, carbohydrate, ash content and crude fibre were observed to be significantly different ($p<0.05$).

The proximate values obtained in this work compare favourably with those reported by Akwaowo *et al.* (2000), Oyolu (1980) and Aletor *et al.* (2002). Oyolu (1980) reported 85% moisture content, while Akwaowo *et al.* (2000) reported 84.48%. Slight differences observed can be attributed to the application of organic fertilizer in the test samples. The crude protein values obtained in this work were higher than 11% reported by Oyenuga (1968) and Oyolu (1980). Age which might be a factor was not actually reported by these authors. Akwaowo *et al.* (2000) however, reported 22.4% crude protein in younger leaves (12 weeks) and 39.4% in older leaves (50 weeks) in contrast to Aletor *et al.* (2002) who reported 34.6% crude protein in fluted pumpkin leaves purchased from the open market in fresh conditions. Differences observed could be attributed to factors like age before harvesting, application of fertilizer, soil history, etc. High nitrogen application to plant foods can increase crude protein concentration but decrease the nutritional value of that protein. This may be because nitrogen from organic fertilizer sources is often released slowly and is therefore less readily available to plants than from chemical sources (Siderer *et al*., 2005). Conventionally cultivated or mineral fertilized vegetables seem to have higher nitrate content than organically produced or fertilized vegetables (Siderer *et al*., 2005). Higher nitrate contents are to be found above all in what are known as nitrophilic leaf, root and tuber vegetables (Siderer *et al*., 2005). This observation also compare favourably with the report of Worthington (2001), where there was no significant difference in protein content of organic and conventional fruits, vegetables and grains. According to Worthington (2001), nitrogen from any kind of fertilizer affects the amounts of vitamin C and nitrates as well as the quantity and quality of protein produced by plants. Thus, when a plant is treated with a substantial amount of nitrogen, the protein production is increased and carbohydrate production will reduce. Similarly in this work, the carbohydrate content was observed to be decreasing with increase in amount of tonnes of PM applied. The ash content and crude fibre values were a little lower than those reported by Akwaowo *et al.* (2000) and Aletor *et al.* (2002).

Table 2 shows the mineral composition of the freshly harvested OGFP and NPK leaves. The values obtained compare favourably with reports of earlier works. The values obtained for K, Cu and Na are slightly lower than the values reported by Akwaowo *et al.* (2000). The values of Fe obtained ranged from 30.21 to 38.93mg/100g db. Akwaowo *et al.* (2000) reported 3.60 mg/100g db for younger leaves and 2.73 mg/100g db for older leaves while Aletor *et al.* (2002) reported 398 mg/kg of Fe in fluted pumpkin leaves. According to Akwaowo *et al.* (2000), phosphorus and zinc play crucial roles in actively metabolizing cells, particularly in relation to energy metabolism while photosynthesizing leaves play key roles in energy cycle. Magnesium and iron are components of chlorophyll. Vegetables are known to supply the needed vitamins, iron, calcium, magnesium, zinc and other minerals important for human health and they are the most affordable source of minerals and vitamins to Africans (Schultink *et al*., 1987; Akwaowo *et al*., 2000). The relatively high concentration of Fe in fluted pumpkin leaves may, perhaps, provide the basis for which extract from the leaves is traditionally administered as a blood tonic to convalescing patients (Akoroda, 1990).

The fluted pumpkin leaves treated with inorganic fertilizer (NPK) had the highest values of K, Fe and Na but lowest values of P, Ca, Mg and Cu as shown in Table 2. According to Virginia (2001), potassium fertilizer can reduce the magnesium content and indirectly the phosphorus content of some plants. When potassium is added to soil, the amount of magnesium absorbed by such plants decreases, because phosphorus absorption depends on magnesium and less phosphorus is absorbed as well. Conventional potassium fertilizers dissolve readily in soil water

Table 1. Proximate composition (% DM) of OGFP at different tonnes (0-15) and NPK leaves

Proximate composition	0	5	10	15	NPK
Moisture	80.09±0.52[d]	82.30±0.31[bc]	82.86±0.69[b]	83.91±0.76[ab]	84.83±0.60[a]
Crude protein	31.67±1.27[a]	32.34±0.66[a]	31.99±1.28[a]	32.56±0.40[a]	32.78±0.40[a]
Fat	8.19±0.21[cd]	9.37±1.07[bc]	10.20±0.35[ab]	10.75±0.35[a]	8.72±0.16[c]
Carbohydrate	44.56±1.29[a]	41.00±1.31[b]	37.52±1.41[c]	34.17±0.54[d]	37.50±0.23[c]
Ash	7.92±0.12[b]	8.15±0.10[b]	10.03±0.09[a]	10.25±0.29[a]	10.15±0.08[a]
Crude Fibre	7.65±0.15[e]	9.03±0.09[d]	10.26±0.37[c]	12.18±0.15[a]	10.76±0.04[b]

Mean values with same superscript in a row are not significantly different (p> 0.05).

Table 2. Elemental Nutrient Composition (mg/100g DM) of OGFP at different tonnes (0-15) and NPK leaves

Elements	0	5	10	15	NPK
Calcium	1.74±0.09[c]	1.84±0.07[c]	2.20±0.10[b]	2.31±0.06[ab]	2.42±0.04[a]
Magnesium	0.50±0.01[d]	0.55±0.02[c]	0.63±0.02[b]	0.69±0.02[b]	0.64±0.02[a]
Potassium	2.03±0.02[d]	2.24±0.05[c]	3.10±0.01[b]	3.15±0.01[b]	3.48±0.06[a]
Sodium	2.96±0.02[e]	3.16±0.02[d]	4.03±0.06[c]	4.16±0.06[b]	4.27±0.04[a]
Zinc	5.41±0.02[d]	5.87±0.02[c]	6.45±0.08[b]	6.68±0.04[b]	6.41±0.01[a]
Copper	0.31±0.01[d]	0.35±0.01[c]	0.47±0.01[b]	0.51±0.01[a]	0.48±0.01[b]
Phosphorus	1.02±0.02[c]	0.99±0.01[c]	1.16±0.03[b]	1.21±0.01[a]	1.17±0.10[ab]
Iron	30.21±0.36[d]	30.65±0.50[d]	32.42±0.38[c]	34.80±0.50[b]	38.93±0.28[a]

Mean values with same superscript in a row are not significantly different (p> 0.05).

presenting plants with large quantities of potassium while organically managed soils hold moderate quantities of both potassium and magnesium in the root zone of the plant (Worthington, 2001). Hence, the higher values of Mg and P in OGFP over NPK leaves can be attributed to the physiological processes highlighted above. Similar observations have been reported by Worthington (2001). The concentrations of the water soluble vitamins (Vitamin C, thiamine and riboflavin) of the samples are presented in Table 3. The Vitamin C contents of the samples were significantly different at 5% level with values ranging between 237.00 and 296.67mg/100g db. The highest value was observed in leaves grown with 15 tonnes of PM while the lowest was in leaves planted without PM or NPK. Vitamin C concentration obtained in this work increased with increase in the tonnes PM applied. Siderer *et al*. (2005) had earlier shown that organically grown crops had higher vitamin C content. No significant difference ($p>0.05$) was observed in thiamine content except in leaves grown without tonnes of PM or NPK. The values obtained ranged between 0.44 and 0.51mg/100g db with the highest value observed from leaves of grown without PM or NPK and lowest value in leaves grown with 5 tonnes of PM. The riboflavin content was significantly different ($p<0.05$), except in leaves grown without PM and NPK. The values obtained ranged between 1.86 and 2.48mg/100g db.

The results of anti-nutrients composition of freshly harvested OGFP and NPK grown leaves in Figure 1 were lower than the values of Akwaowo *et al.* (2000). The cyanide content of the leaves ranged between 0.60 mg/100g db and 0.64 mg/100g db. This amount is below the safe limit of cyanide content (1mg/100g DM) reported for garri (IITA, 1990). Hence, its consumption cannot affect human nutrition even in large quantities. The oxalate and phytate content are highest in fluted pumpkin leaves treated with NPK fertilizer while samples obtained without treatment with PM has highest value of tannins. Tannins, oxalates and phytates are known to affect human nutrition processes and metabolic activities (Akwaowo *et al.*, 2000). For example, high oxalate content reduces bioavailability of calcium. It was reported that oxalate form insoluble complexes with calcium, magnesium, zinc and Fe, thereby interfering with utilization of these mineral elements (Akwaowo *et al.*, 2000). Tannic acid has been associated with lower nutritive value of protein. Higher intake has

Table 3. Water soluble vitamins (mg/100g DM) of OGFP at different tonnes (0-15) and NPK leaves

Proximate composition	0	5	10	15	NPK
Vitamin C	237.00±3.61[e]	258.00±2.64[d]	276.00±1.00[b]	296.67±3.78[a]	269.33±5.51[c]
Thiamine	0.51±0.01[a]	0.44±0.02[b]	0.47±0.027[b]	0.45±0.01[b]	0.45±0.01[b]
Riboflavin	2.27±0.02[b]	1.86±0.02[d]	2.07±0.06[c]	2.25±0.06[b]	2.18±0.22[c]

Mean values with same superscript in a row are not significantly different (p> 0.05).

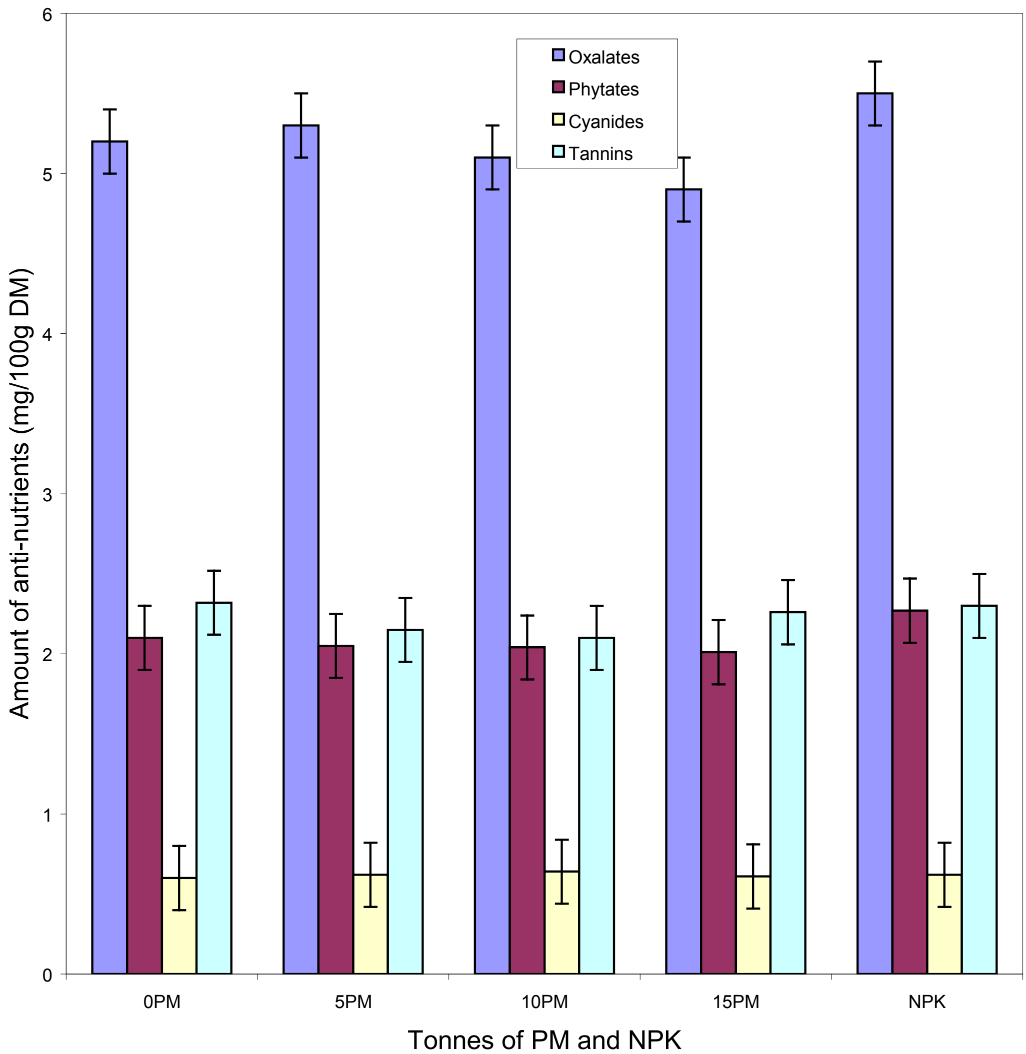

Figure 1. Anti-nutrients composition (mg/100g DM) of OGFP and NPK leaves

been associated with cancer in man, poor protein utilization, liver and kidney toxicity (Singleton and Kratzer, 1969). Phytic acid intake of about 4-9 mg/100g DM has also been reported to decrease iron absorption by 4-5 fold in humans (Hurrel *et al.*, 1992) in this study, these values were lower. However, Dunu *et al.* (1986), explained that most of these toxicants are, in general, eliminated during the stages of processing, especially when heat is involved.

The comparison of the data on the percentage loss (or otherwise retention) of water soluble vitamins (vitamin C, thiamine and riboflavin) from the leafy vegetables over the entire range of experimental conditions investigated reveals very similar characteristics trend as shown in Figures 2 to 7. Drying at 50 to 60^oC in 30 minutes resulted in 2.02 to 12.01% loss of vitamin C, 3.92 to 13.33% loss of thiamine and 5.75 to 12.17% loss of riboflavin. The range of values recorded after 180 minutes of drying increased to about 29.35 to 37.07%, 26.67 to 32.61% and 25.65 to 31.30% losses, respectively, as shown in figures 2 to 7. The leaves of fluted pumpkin planted with inorganic fertilizer (NPK 90kg/ha) had the highest concentration of losses among the three water soluble vitamins considered. As expected the percentage losses of the water soluble vitamins increased as the temperature and drying time also increased. Other researchers have reported up to 66%, 70%, and 44 to 90% in cooked and blanched vegetables (Omueti and Adepoju, 1988; Oguntona, 1988; and Solanke and Awonorin, 2002). Table 4 summarizes the regression constants and coefficients suitable for the prediction of retention of water soluble vitamins as a function of drying temperature, drying time and tonnes of PM applied during sowing. The high values of the coefficient of determination (ranging between 0.907 – 0.951) shows the reliability of the suggested model.

The intensity of heat on the concentration of water soluble vitamins (Vitamin C, thiamine and riboflavin) during drying of samples (or otherwise the loss of these vitamins) correlated positively with temperature for the fluted pumpkin leaves as shown in Table 5. The ranges of values are: 0.0011 to 0.022 s^{-1} for vitamin C, 0.00024 to 0.00167s^{-1} for riboflavin and 0.00122 to 0.00195 s^{-1} for thiamine. The temperature-dependent effects of drying on the activation energy, E_a and pre-exponential constant k_o are presented in Table 6. The values of E_a obtained ranged from 14.64 to 72.98 kg/g mol, 1.23 to 45.92 kg/g mol and 4.87 to 34.29 kg/g mol for vitamin C, thiamine and riboflavin, respectively. For vitamin C and riboflavin, highest value of E_a was observed in fluted pumpkin leaves with 0 tonnes of organic fertilizer and the lowest value in fluted pumpkin leaves where10 tonnes organic fertilizer was used. For thiamine, the highest value of E_a was observed from leaves where 0 tonnes organic fertilizer was used, while the lowest value was observed in leaves involving the application of 15 tonnes organic fertilizer.

The intensity of heat on the concentration of the water soluble vitamins in the samples, or otherwise, the loss of it correlated positively with temperature for the five samples of fluted pumpkin leaves. Maximum values of rate constant, k were obtained for vitamin C degradation. The lower values of rate constants k obtained for thiamine and riboflavin degradation were significant indications of the ease of thermal degradation of these vitamins compared with vitamin C. Higher values of activation energy E_a were also observed in vitamin C degradation when compared with other water soluble vitamins considered. The activation energy is an entropy potential which evaluates the quality changes in the food system from the estimates of the rate constant using process temperature as the cause-and-effect driving force (Solanke and Awonorin, 2002). The mechanism of degradation of water soluble vitamins (vitamin C, thiamine and riboflavin) in the fluted pumpkin leaves during drying appeared to be dependent on thermally induced energy intensity on physico-chemical changes rather than the composition of the vegetables (Solanke and Awonorin, 2002).

Conclusions

From the present study, OGFP leaves contained significantly more magnesium, calcium, phosphorus and copper. The fluted pumpkin leaves obtained from experimental treatment using 15 tones of organic fertilizer (poultry manure) had highest nutrient composition. The overall analysis comparing the nutrients, vitamins and some mineral composition of organic and inorganic fluted pumpkin leaves did not show superior nutritional advantage of the vegetables grown using poultry manure over those grown using NPK fertilizer. The losses of water soluble vitamins from the fluted pumpkin leaf samples depended on changes induced by thermal intensity of the hot air drying medium, which must be kept to minimum levels in order to enhance their retention in the final product. The degradation of water soluble vitamins as evaluated using the first-order kinetic models was found to be accurate for all the samples and, as expected a function of process temperature and time.

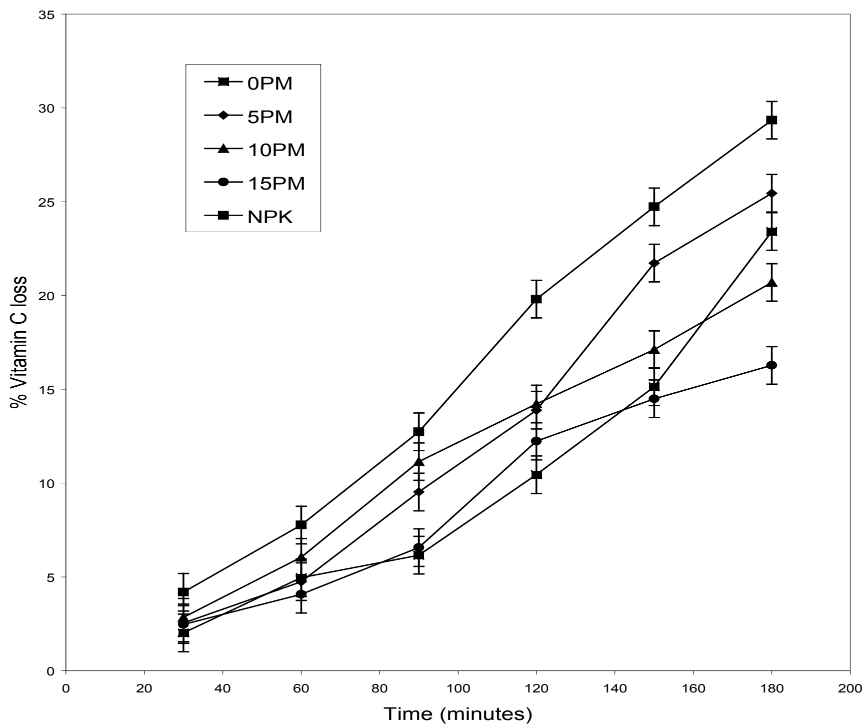

Figure 2. Vitamin C loss as affected by tonnes of PM and NPK at drying temperature of 50°C

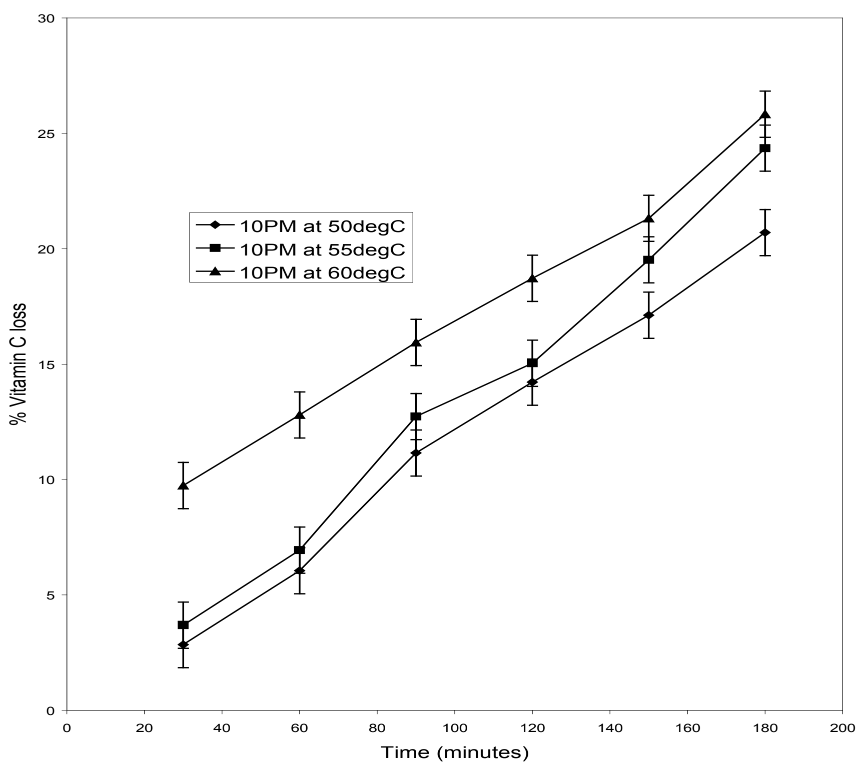

Figure 3. Effect of drying on % Vitamin C loss of OGFP leaves sown with 10 tonnes of PM

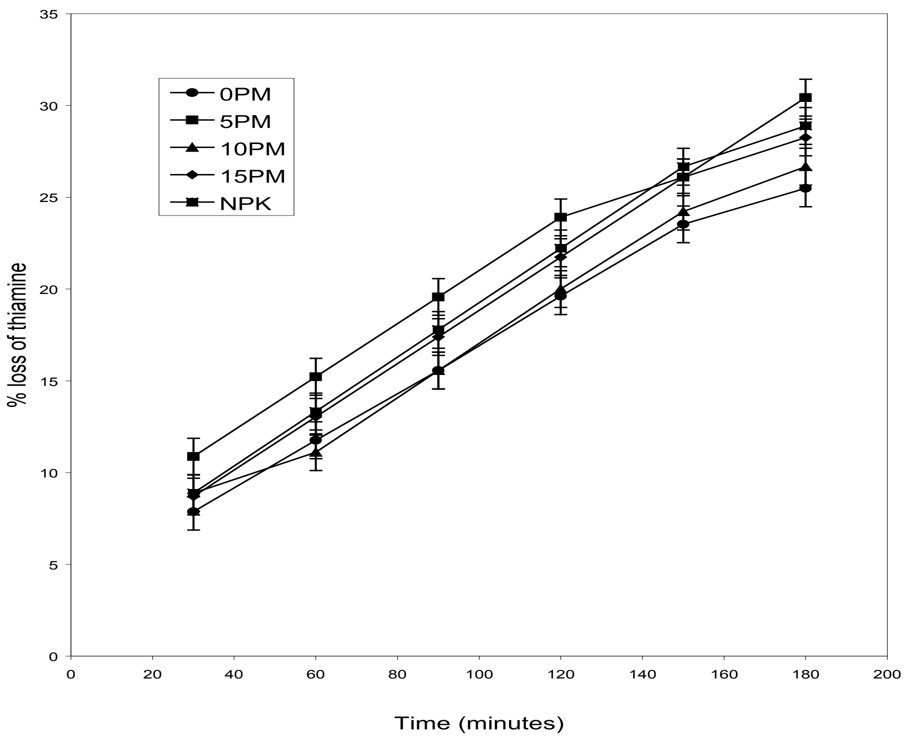

Figure 4. % loss of Thiamine as affected by tonnes of PM and NPK at drying temperature of 55°C

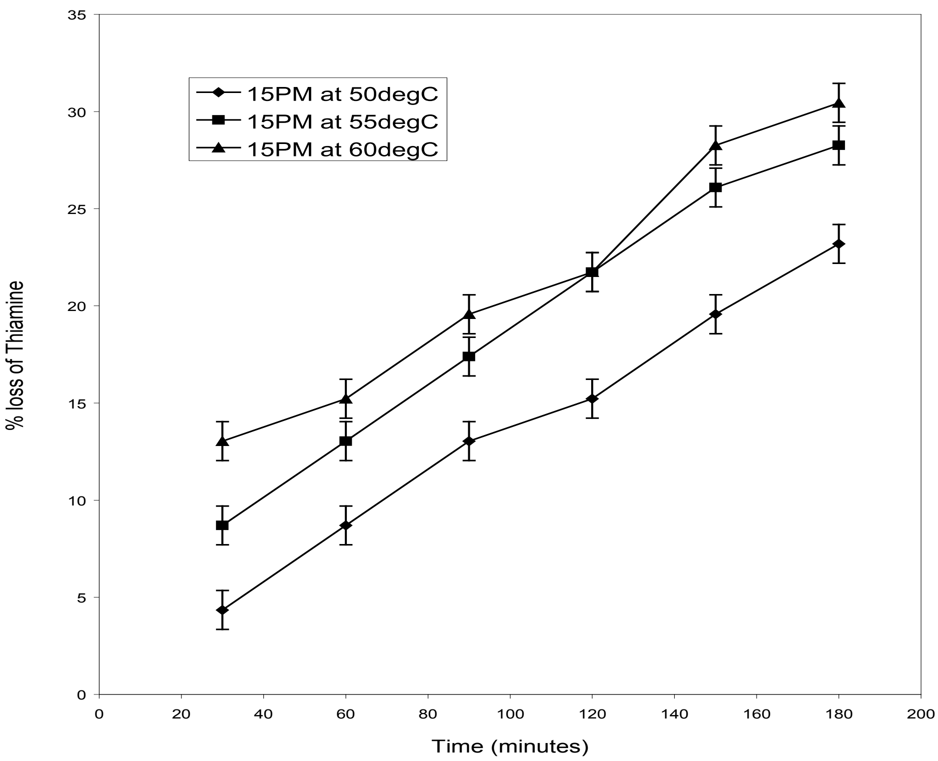

Figure 5. % loss of Thiamine using 15 tonnes of PM at different drying temperature

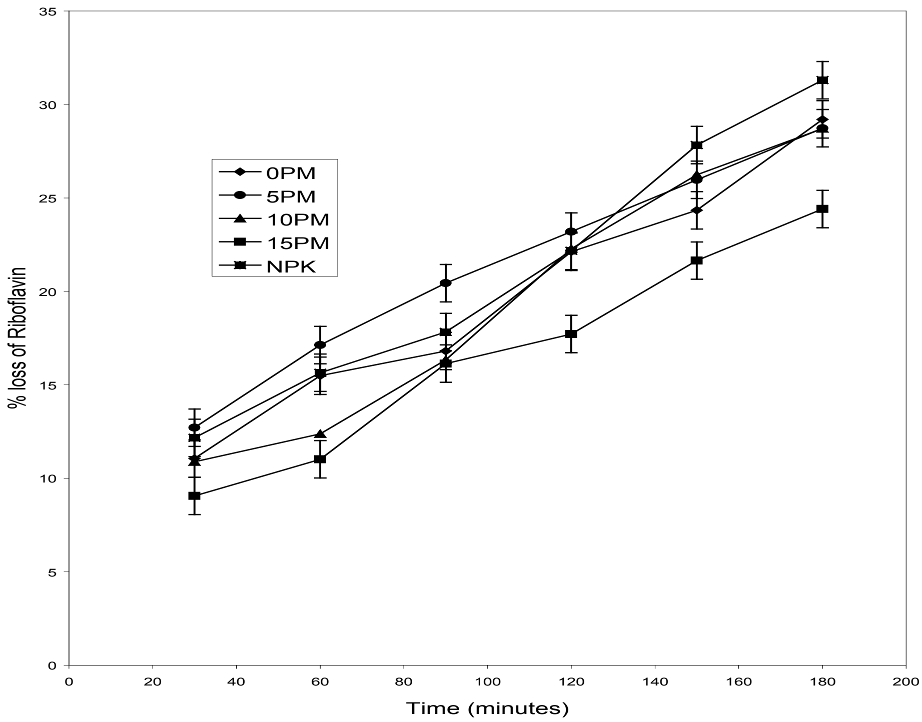

Figure 6. Figure 6. % loss of Riboflavin as affected by tonnes of PM and NPK at drying temperature of 60°C

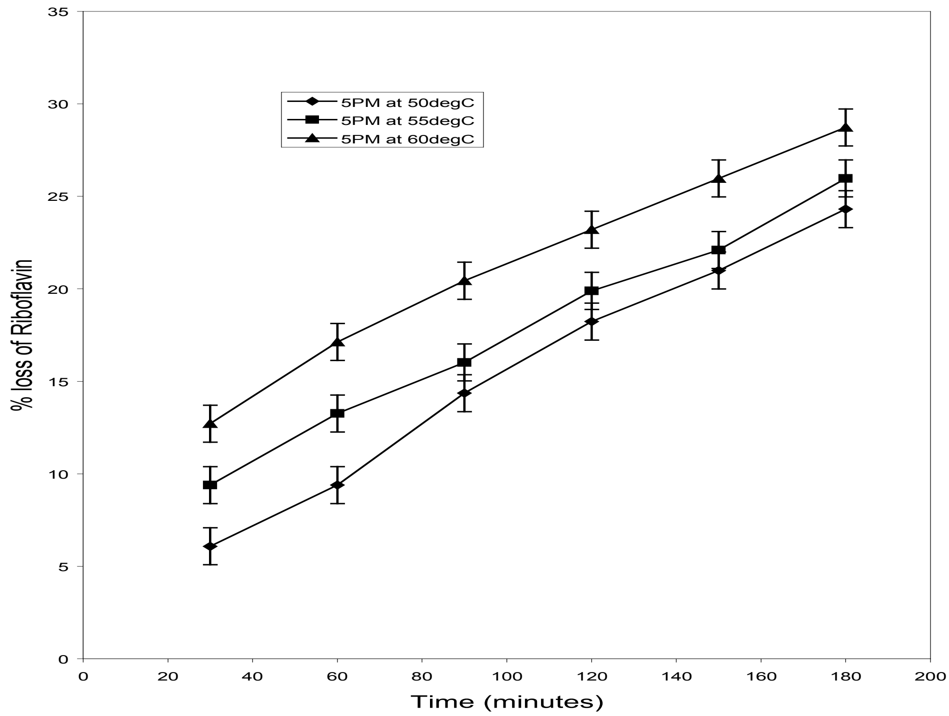

Figure 7. % loss of Riboflavin as affected by temperature of drying using 5 tonnes of PM

Table 4. Regression constants of water soluble vitamins in OGFP leaves

Vitamins	β_0	β_1	β_2	β_3	R^2
Vitamin C	130.84	-0.567	-0.137	0.118	0.907
Thiamine	124.19	-0.522	-0.122	0.085	0.923
Riboflavin	126.65	-0.596	0.113	0.198	0.951

Table 5. The degradation rate constant (K/sec) of vitamins as a function of temperature and time of drying in OGFP and NPK leave

Vitamin	Temperature	0	5	10	15	NPK
VitamiVitamin C	50	0.00152	0.00188	0.00136	0.00110	0.00172
	55	0.00200	0.00199	0.00159	0.00114	0.00210
	60	0.02200	0.02140	0.00126	0.00125	0.00236
ThiamThiamine	50	0.00144	0.00154	0.00154	0.00148	0.00195
	55	0.00144	0.00162	0.00165	0.00166	0.00177
	60	0.00122	0.00149	0.00158	0.00148	0.00156
RiboflRiboflavin	50	0.00126	0.00146	0.00158	0.00024	0.00155
	55	0.00144	0.00131	0.00140	0.00108	0.00154
	60	0.00147	0.00132	0.00162	0.00126	0.00167

Table 6. Thermo-resistance parameters of some water soluble vitamins during drying of OGFP and NPK leaves

Vitamins	PM and NPK	E_a (kg/g mol)	K_o (per seconds)	R^2
Vitamin C	0	72.98	3.52 x 102	0.931
	5	25.51	7.16	0.993
	10	14.64	8.14 x 103	0.983
	15	25.11	1.31 x 101	0.935
	NPK	65.20	6.60 x 101	0.980
Thiamine	0	33.96	1.64 x 103	0.942
	5	6.65	1.86 x 103	0.947
	10	5.41	2.65 x 102	0.914
	15	1.23	1.00 x 103	0.981
	NPK	4.59	8.64 x 103	0.993
Riboflavin	0	31.84	4.52	0.954
	5	20.87	2.03 x 103	0.901
	10	4.87	3.00 x 102	0.923
	15	34.28	1.13 x 102	0.925
	NPK	15.27	5.54 x 101	0.977

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