Journal of McPherson University (HUMASS) *2019,* ***2****(1): 162-175*
ISSN: 2630-6514
https://doi.org/10.6084/m9.figshare.9959618

NUTRITIONAL QUALITIES, FUNCTIONAL PROPERTIES AND THERMAL PROPERTIES OF DRIED FRUIT OF NEGRO PEPPER

Oso BJ[1, 2*], Oladiji AT[2]
[1]Department of Biochemistry,
McPherson University, Seriki-Sotayo, Ogun State, Nigeria
[2]Department of Biochemistry,
University of Ilorin, Ilorin, Kwara State, Nigeria
*Correspondence: basjoe08@gmail.com

Abstract

This research assessed the nutritional, functional and thermal properties of pulverised fruit of Negro pepper. The proximate analysis was performed using the standard methods and mineral contents were determined using atomic absorption spectrometry. The functional properties (bulk density, swelling capacity, water absorption capacity, oil absorption capacity and foam capacity) of pulverised sample were also evaluated while the thermal properties were obtained using the mass fractions derived from the proximate compositions and the bulk density. The crude protein, crude lipids and crude fibres were 9.22±0.32%, 14.67±0.32% and 22.67± 1.63% respectively. The ash contained an appreciable amount of calcium (29.40±2.63 mg/100g), sodium (13.60±1.22 mg/100g) and magnesium (8.50±2.83 mg/100g). Negro pepper had high bulk density (435.19±18.59 kg/m$^{3)}$, swelling capacity (346.44±3.99%), water absorption capacity (91.15±1.52 %), oil absorption capacity (43.26±1.87%) and foaming capacity (1383.25±43.31%). The pH and titratable acidity values were 9 and 2.98±0.23 mg/100g, respectively while the specific heat capacity, thermal conductivity and thermal diffusivity were correspondingly 1.16±0.096 KJ/kg·K, 0.16±0.03W/m·K and 0.0034±0.001m^2/s. The present study inferred that Negro pepper might serve as a good source of protein and calorie as well as micronutrients for human consumption. Moreover, the powdered fruit has good functional properties which could suggest its use as a natural additive in food processing.

Keywords: Negro Pepper; Spice; Anti-nutrient; Functional Properties; Natural Additives.

Introduction

Spices are usually dried plant materials that are used to impart flavour and aroma in food preparation. Common examples include garlic, Negro pepper, onion, ginger, curry, thyme, Africa nutmeg and black pepper. Beside their use as condiments in food preparations, the main chemical components of these spices confer other properties giving them optimistic versatile applications in industry and medicine (De La Torre *et al.*, 2017). Some spices with preservative potential have been suggested as a replacement for synthetic preservatives, such as nitrates (Anand and Sati 2013). Their applications in food processing may lessen the controversies that are associated with synthetic additives. Moreover, they are essential in the preparation of traditional medicinal decoctions for treatments and managements of diverse ailments. Despite the extensive applications of many of these spices, some are limited to culinary preparation of local dishes and their potential use in food industries have been less studied. The powdered fruit of Negro pepper (*Xylopia aethiopica* (Dunal) A. Rich (family Annonaceae) is one of the major spices that are regularly used in preparations of local foods in sub-Sahara Africa. It is commonly called Erunje or Erinje in Yoruba, Uda in Igbo, Kimba in Hausa, Hwentia in Akan-Asante, Evafé in Abure and Kaani in Mandinka (Burkill 1985). Its extractive is also prescribed as conventionally folk medicine for the treatment of ailments associated with inflammatory disorders and as a postpartum tonic (Oso *et al.*, 2017; Oso *et al.*, 2018a). Prophylactic oral administration of ethanolic extract of the fruit has been shown to have protective effect against turpentine oil-induced acute inflammation in splenic tissues of Wistar rats (Oso *et al.*, 2018b). It has also been proposed to have preservative properties against spoilage (Babarinde and Adegoke 2015). Earlier data presented on the proximate and mineral compositions of Negro pepper grown in different parts of sub-Sahara Africa reported varying findings on the proportions of nutrient compositions of the fruits (Abolaji *et al.*, 2007; Borquaye *et al.*, 2017; Bouba *et al.*, 2012; Dike 2010; Osabor *et al.*, 2015). The discrepancies in the findings may be associated with varieties and local climate conditions of the region. In spite of the high nutritional potential, medicinal properties, and the cultivation, the use of the fruits of Negro pepper remains limited in food processing industry. This might however be as a result of limited data available on quality assessment, design, and evaluation. The present study was carried out to evaluate the qualities of pulverised dried fruit of Negro pepper collected from North Central region of Nigeria and provide data on the nutritional structures, mineral compositions, functional and thermal properties in order to explore its potential use in food industry as a natural additive.

Materials and Methods

Fresh fruits of Negro pepper were collected from different locations in the North central region of Nigeria. The fruits were air-dried, pulverised and stored in an air-tight container. The chemicals used were of analytical grade.

Proximate Analysis

Proximate analysis of the dried fruit of Negro pepper was carried out according to the standard procedure of Association of Official Analytical Chemists, AOAC (2005). The moisture content of the fresh material was determined gravimetrically by oven drying the sample at 100^oC to constant weight based on moisture evaporation. The crude protein content was determined by the Kjeldahl method which is based upon the determination of the amount of reduced nitrogen present and multiplied by a factor of 6.25, general factor for natural products in which the equivalent of specific proteins are not well defined. Lipid content of the sample was determined by the semi-continuous petroleum ether extraction method using Soxhlet apparatus for 6 hours. The percentage lipid content was calculated as the ratio of the lipids extracted by the petroleum ether to the original weight of the sample multiplied by 100. Ash content, which represents the inorganic component (minerals) of the sample, was determined gravimetrically after it was allowed to blast for 3 hours at 550^oC in a muffle furnace and subsequently, the percentage ash content was calculated as the ratio of ash obtained to the original weight of the sample multiplied by 100. Bulk of roughages, usually referred to as the crude fibre, were determined gravimetrically from the petroleum ether-defatted sample as the estimation of portion remaining after sequential digestion with 1.25 % sulphuric acid and

1.25 % sodium hydroxide solutions, oven-drying at 104^{o}C and ignition in muffle furnace at 550^{o}C for 3 hours. The percentage crude fibre was calculated as ratio of organic matter after digestion to the weight of the original sample multiplied by 100. Carbohydrate content of the sample was estimated as the difference obtained after subtracting the summation of the protein content, lipid content, ash content and crude fibre from 100.

Anti-nutritional Compositions of Negro pepper

The free phytate in the sample was digested according to the method described by Harland and Oberleas (1977) and the liberated organic phosphorus was measured spectrophotometrically at 680 nm. The amount of phytate was calculated from the organic phosphorus by assuming that one molecule of phytate contained six molecules of phosphorus. Oxalate in the sample was estimated using redox titration based on the reaction of oxalate with potassium permanganate as described by Falade, *et al.* (2005). The concentration of oxalate in the sample was obtained by presuming that 1 ml of 0.1N permanganate = 0.006303 g oxalate AOAC (2005) and expressed as the calcium oxalate equivalents. Moreover, the amount of saponins in the sample was determined according to the method described by Obadoni and Ochuko (2001) while the tannins in the sample were estimated using the Vanillin-HCl method described by Burns (1971) and expressed as Gallic acid equivalent mg/100g of the dried sample.

Mineral analyses

The method described in AOAC (2005) was used for mineral analysis. The sample was turned to ash at 550°C. The ash was boiled with 10 ml of 20 % hydrochloric acid in a beaker and then filtered into a 100 ml standard flask. This was made up to the mark with deionized water. The minerals were determined from the resulting solution using Atomic Absorption Spectrophotometer. Phosphorus was determined colorimetrically in accordance with the method described by Kirk and Sawyer (1991) with KH_2PO_4 as the standard. All the values were expressed in mg/100g.

Functional properties

Functional properties of the pulverized sample of Negro pepper were determined. Bulk density was estimated through 'tamping procedure' as described by Ahmedna *et al.* (1997). The swelling capacity was determined by the method described by Okaka and Potter (1977). The water absorption capacity of the pulverised sample was determine by the method of Sosulski *et al.* (1976). The water absorption capacity was expressed in percentage in relation to the original weight of the sample. The procedure was repeated using olive oil instead of distilled water for the determination of oil absorption capacity. The foaming capacity of the sample was estimated as described by Narayana and Narasinga (1982). The pH was measured using a digital pH meter while titratable acidity was determined with NaOH solution and phenolphthalein as indicator. The result was expressed as mg/100g of the dried fruit.

Thermal properties

Determination of specific heat capacity

The specific heat capacities of the samples were estimated from the respective mass fractions of carbohydrate, protein, fat, ash and moisture contents of the sample using the expression defined by Choi and Okos (1986).

$$Cp = (4.180\mathrm{Mm} + 1.711\mathrm{Mp} + 1.929\mathrm{Mf} + 1.547\mathrm{Mc} + 0.908\mathrm{Ma})$$

Where Cp is the specific heat capacity while Mm, Mp, Mf, Mc and Ma and are the respective mass factions of moisture, protein, fat, carbohydrate and ash contents of the sample.

Determination of thermal conductivity

The thermal conductivities of the samples were estimated from the respective mass fractions of carbohydrate, protein, fat, ash and moisture contents of the sample using the expression defined by Sweat (1986).

$$k = (0.25\ \mathrm{Mc} + 0.155\ \mathrm{Mp} + 0.16\ \mathrm{Mf} + 0.135\ \mathrm{Ma} + 0.58\ \mathrm{Mm})$$

Where k is thermal conductivity while Mc, Mp, Mf, Ma and Mm are the respective mass fractions of carbohydrate, protein, fat, ash and moisture contents of the sample.

Determination of thermal diffusivity

Thermal diffusivities of the samples were determined using the following expression:

$$\alpha = \frac{k}{\rho \times Cp} (m^2/s)$$

Where α is thermal diffusivity, k is the thermal conductivity, ρ is the density and Cp is the specific heat capacity.

Results and Discussion

The results of the nutritional and anti-nutritional of the dried fruit of Negro pepper are shown in Tables 1 and 2. The nutrient compositions include moisture (8.33±0.24 %), ash (4.26±0.1 %), crude fibre (22.67±63 %), crude protein (9.22±0.32 %), carbohydrate by difference (41.26±2.23 %) and energy (kcal/100g) 324.67±67. The antinutritional factors present in the dried fruit include phytate (1.66±0.04 mg/100g), and oxalate (3.62±1.67 mg/100g), saponins (25.67±2.17 mg/100g) and tannins (5.62±2.67 mg/100g). The findings of the mineral composition are presented in Table 3. The dried fruit is rich in calcium (29.40±2.63 mg/100g), sodium (13.60±1.22mg/100g), magnesium (8.50±2.83mg/100g) and iron (6.10±0.84 mg/100g). Moreover, the dried fruit contains a substantial amount of zinc (3.40±0.72mg/100g) and phosphorus (34.00±06.23mg/100g) and low levels of copper (0.50±0.07mg/100g), manganese (0.60±0.02mg/100g) and potassium (1.46±0.73mg/100g). The powdered sample had high bulk density (435.19±18.59 $kg/m^{3)}$, swelling capacity (346.44±3.99 %), water absorption capacity (91.15±1.52 %), oil absorption capacity (43.26±1.87 %) and foaming capacity (1383.25±43.31 %) while the pH and titratable acidity values were 9 and 2.98±0.23mg/100g, respectively (Table 4). Table 5 shows the thermal properties data of the Negro pepper. The average values of the specific heat capacity, thermal conductivity and thermal diffusivity are 1.16±0.096 J/kg·K, 0.16±0.03W/m·K and 0.0034±0.001m^2/s, respectively.

Table 1: Nutritional compositions of the fruit of Negro pepper

Nutrient	Composition
Moisture (%)	8.33±0.24
Crude Protein (%)	9.22±0.32
Crude Lipids (%)	14.67±0 .32
Ash Content (%)	4.26±0.13
Crude Fibre (%)	22.67±1.63
Carbohydrate (%)	41.26±2.23

Each value represents the mean ± SD of three determinations

Table 2: Anti-nutritional compositions of the fruit of Negro pepper

Anti-nutrient	Composition
Oxalate (mg/100g)	3.62±1.67
Phytate(mg/100g)	1.66±0.04
Saponins (mg/100g)	25.67±2.17
Tannins (mg GAE/100g)	5.62±2.67

Each value represents the mean ± SD of three determinations on dry weight basis, GAE= Gallic Acid Equivalent

Table 3: Some mineral constituents of the fruit of Negro pepper

Element	Composition (mg/100g)
K	1.46±0.73
Ca	29.40±2.63
Iron	6.10±0.84
Mg	8.50±2.83
Na	13.60±1.22
Zn	3.40±0.72
Cu	0.50±0.07
Mn	0.60±0.02
P	34.00±6.23

Each value represents the mean ± SD of three determinations

Table 4: Functional properties of Negro pepper

Parameter	Mean ± SD
Bulk density (Kg/m^3)	435.19±18.59
Swelling capacity (%)	346.44±3.99
Water absorption capacity (%)	91.15±1.52
Oil absorption capacity (%)	43.26±1.87
Foaming capacity (%)	1383.25±43.31
pH	9
Titratable Acidity (mg/100g)	2.98±0.23

Each value represents the mean ± SD of three determinations on dry weight basis.

Table 5: Thermal properties of Negro pepper

Parameter	Mean±SD
Specific Heat Capacity (J/kg·K)	1.16±0.096
Thermal Conductivity (W/m·K)	0.16±0.003
Thermal diffusivity (m^2/s)	0.0034±0.001

Each value represents the mean ± SD of three determinations on dry weight basis.

The results presented revealed that the fruits and seeds could serve as a cheap source of protein, energy, as well as antioxidant micronutrients supplements for both man and animal. The protein content was consistent with percentage reported by other authors (Borquaye *et al.*, 2017; Bouba *et al.*, 2012; Dike, 2010; Osabor *et al.*, 2015); however it was remarkably higher than the value reported by Abolaji *et al.* (2007). Moreover, comparatively low fat content reported in this work as compared to those reported in literature (Bouba *et al.*, 2012; Tchiegang and Mbougueng 2005) might be attributed to the difference in the extraction methods. The crude fibre and the lipid contents were relatively higher compared to those reported for other spices such as ginger and garlic (Okolo *et al.*, 2012). Crude fibre is the quantity of indigestible cellulose, pentosans and lignin; studies had shown that adequate intake of crude fibre is related to obesity prevention and also provide the bulk necessary for proper peristaltic action in intestinal tract (deVrese and Schrezenmeir 2008). Lignin had been acknowledged as a binding agent in crude fibre which acts to lessen the concentration of low density lipoprotein (LDL) cholesterol in the blood. Additionally, Bouba *et al.* (2012) reported that *X. aethiopica, Monodora myristica* (calabash nutmeng) and *Fagara leprieuri* (prickly ash) compared to other oils sources (olive, palm, soy, and groundnuts) could be considered as good sources of fat. The lipid content which might include the fat soluble phytochemicals such as fatty acids, tocopherols, carotenoids, lycopenes, sterols, terpeniods and the glycerides perform various functions in the cell such as storing energy, signalling, and acting as structural components of cell membrane. Majority of these lipids such carotenoids, terpenoids and tocopherol are phytochemicals which have been shown to possess characteristic biological properties such as antioxidant and modulation of immune response (Hart *et al.,* 2000; Kamatou *et al.,* 2006; Yesilada *et al.,* 2005). The antinutritional factors which are accountable for the toxic effects that are related to nutrient absorption and bioavailability were relatively low in the sample. However, their presence suggests that the fruit must be processed before consumption. For instance, high phytate content has been shown to add to the increase of human zinc deficiency and alongside protein utilisation (Harland and Harland 1980, Harland and Oberleas 1977). Phytate content of Negro pepper is relatively low compared to wheat bran (3.70 %), soybean (2.58 %), barley (1.19 %) and oat (0.77 %) (Harland and Harland 1980); the level is not likely to cause any threat compared with garlic (32.2 %), broccoli (12.4 %) and cabbage (10.2 %) (Santamaria *et al.,* 1999). However, some antinutrients such as tannins could exert beneficial biological activities such as antimicrobial, anti-viral and antifungal (Chung *et al.,* 1998). In addition, saponins repress the absorption of alcohol, cholesterol and iron in the digestive system (Falade *et al.,* 2005). The amounts of mineral compositions in the present study differ greatly compare with those reported by other authors except the low levels of copper and manganese which were comparable with those of Abolaji *et al.* (2007) and Osabor *et al.* (2015). The observed incongruence may be due to varietal variances and the locality.

Furthermore, the functional properties and engineering properties of the spice were evaluated. These properties provide predictive analytical information on the quality of the spice and its behaviour in food processing. The sample had high bulk density which is the quantity of its volumetric mass. This showed commercial advantage of Negro pepper with respect to packing and logistics. Large quantity of the sample could be packaged into a unit volume of packaging material. This property also describes its usefulness as a thickening agent. Similarly, the high swelling capacity describes the degree of hydration and swelling of starch granules with water retention ability (Asaoka *et al.*, 1992). Water and oil absorption capacities define the characteristics of the sample under limited availability of water and oil, respectively with reference to its bind with water and oil. These provide useful information on the sample's handling in wet processing in food industry. The result obtained showed that the sample has a good ability to bind water and oil. This study indicated that the sample had extensively great foaming capacity which suggested its potential as foaming agent in food industry. The measure of the acidity or alkalinity of the sample was presented by the estimates of the pH and titratable acidity. The values of these quantities are used to assess the quality of the spice. The thermal properties of samples are required to provide essential features on heat transfer and the design of ambient and cryogenic processing equipment for the sample. Specific heat capacity defines the quantity of heat required to change the temperature of unit mass by unit degree at a given temperature (Stroshine and Hamann, 1994). The anisotropic heat conducting ability of the spice during thermal processing is expressed as thermal conductivity while thermal diffusivity determine the rate at which heat changes in a unit quantity of the spice.

Conclusion

The study revealed that Negro pepper is a rich source of nutrients; however, the observed incongruence in the proximate and mineral compositions of the fruit when compared to earlier reports by other authors was attributed to varietal variances and differences in local climate conditions of the regions where the samples were collected. Moreover, the fruit contains trace amount of antinutrients such as phytate, oxalate, tannins and saponins which suggests that it must be processed before consumption. The functional properties and engineering properties of the spice provide analytical information on the quality of the spice and its behaviour in food processing thus providing a good scope for its utilisation in food industry especially as nutritional additives.

Competing interests

Not applicable

References

Abolaji, A. O., Adebayo, A. H., Odesanmi, S. O. (2007): Nutritional Qualities of Three Medicinal Plant Parts (*Xylopia aethiopica, Blighia sapida* and *Parinari polyandra*) commonly used by Pregnant Women in the Western Part of Nigeria. *Pak J of Nutrition.* 6(6): 665-668.

Ahmedna, M., Johns, M. M., Clarke, J. J., Marshall, W. E., Rao, M. M. (1997): Potential of agricultural by-product-based activated carbons for use in raw sugar decolorisation. *J. Sci. Food Agric*. 75: 117-124.

Anand, S. P., Sati, N. (2013): Artificial Preservatives and Their Harmful Effects Looking toward Nature for Safer Alternatives. *Int J Pharm Sci and Res*. 4: 2496-2501.

AOAC (2005) Official Methods of Analysis of the Association of Official Analytical Chemist. 18th Ed. Washington D.C.

Asaoka, M., Blanshard, J. M. V., Rickard, J. E. (1992): Effects of cultivar and growth season on the gelatinization properties of cassava (*Manihot esculenta*) starch. *J. Sci. Food Agric*. 59: 53 – 58.

Babarinde, G. O., Adegoke, G. O. (2015): Effect of *Xylopia aethiopica* aqueous extract on antioxidant properties of refrigerated Roma tomato variety packaged in low density polyethylene bags. *J. Food Sci Technol.,* 52(3): 790–795.

Borquaye, L. S., Darko, G., Laryea, M. K., Gasu, E. N., Amponsah, N. A. A., Appiah, E. N. (2017): Nutritional and anti-nutrient profiles of some Ghanaian spices. *Cogent Food & Agriculture* 3: 1348185.

Bouba, A. A., Njintang, N. Y., Foyet, H. S., Scher, J. M., Mbofung, C. M. F. (2012): Proximate Composition, Mineral and Vitamin Content of Some Wild Plants Used as Spices in Cameroon. *Food and Nutrition Sciences* 3: 423-432.

Burkill, H. M. (1985): The Useful Plants of West Tropical Africa, Families A-D," Royal Botanic Gardens, Kew, p. 960.

Burns, R. E. (1971): Method of estimation of tannin in the grain sorghum. *Agron.J*. 63: 511–512.

Choi, Y. M., Okos M. R. (1986): Thermal properties of liquid foods: Review. In: Physical and chemical properties of food M.R. Okos (ed), St. Joseph Minnesota: American Society of Agricultural Engineers pp. 35-77.

Chung, K. T., Wong, T. Y., Wei, C. I., Huang Y. W., Lin, Y (1998) Tannins and human health: a review. *Critical Reviews in Food Science and Nutrition.* 38(6): 421-464.

De La Torre, J. E., Gassara, F., Kouassi, A. P., Brar, S. K., Belkacemi, K. (2017): Spice use in food: Properties and benefits. *Critical Reviews in Food Science and Nutrition* 57(6): 1078-1088.

deVrese, M., Schrezenmeir, J. (2008): Probiotics, prebiotics, and synbiotics. *Adv Biochem Eng Biotechnol*. 111: 1-66.

Dike, M. C., (2010): Proximate, phytochemical and nutrient compositions of some fruits, seeds and leaves of some plant species at Umudike, Nigeria. *ARPN J of Agric and Biol Science*. 5(1): 7-16.

Falade, M. S., Owoyomi, O., Harwood, C. E., Adewusi, S. R. A. (2005): Chemical composition and starch hydrolysis of *Acacia colei* and *Acacia tumida* seeds. *Cereal Chemistry* 82(5): 479–484.

Harland, B. F., Harland, J. (1980): Fermentative reduction of phytate in rye, white, and whole wheat breads. *Cereal Chemistry*. 57(3): 226–229.

Harland, B. F., Oberleas, D. (1977): A modified method for phytate analysis using an ion exchange procedure: Application to textured vegetable proteins. *Cereal Chemistry*. 54(4): 827–832.

Hart, P. H., Brand, C., Carson, C. F., Riley, T. V., Prager, R. H., Finlay-Jones, J. J. (2000): Terpinen-4-ol, the main component of the essential oil of *Melaleuca alternifolia* (tea tree oil), suppresses inflam¬matory mediator production by activated human monocytes. *Inflamm Res*. 49(11): 619–26.

Kamatou, G. P. P., vanZyl, R. L., vanVuuren, S. F., Viljoen, A. M., Figueiredo, A. C., Barroso, J. G., Pedro, L. G., Tilney, P. M. (2006): Chemical composition, leaf trichome types and biological activities of the essential oils of four related Salvia species indigenous to Southern Africa. *J. Essent. Oil Res*. 18: 72-79.

Kirk, S. R., Sawyer, R. (1991): Pearson's composition and Analysis of foods, 9th edn., Longman Scientific and Technical, UK.

Narayana, K., Narsinga, R. M. S. (1982): Functional properties of raw and heat processed winged bean (*Psophocarpus tetragonolobus*) flour. *J. Food Sci.* 42:534-538.

Obadoni, B. O., Ochuko, P. O (2001): Phytochemical studies and comparative efficacy of the crude extracts of some Homostatic plants in Edo and Delta States of Nigeria. Global *J. Pure Appl. Sci.* 8b: 203-208.

Okaka, J. C., Potter, N. N. (1977): Functional and storage properties of cow pea-wheat flour blends in bread making. *J. Food Sci.* 42: 828-833.

Okolo, S. C., Olajide, O. O., Idowu,.D. I., Adebiyi, A. B., Ikokoh, P. P., Orishadipe, A. T. (2012): Comparative Proximate Studies on Some Nigerian Food Supplements. *Annals of Biological Research.* 3 (2): 773-779.

Osabor, V. N., Bassey, F. I., Ivara, S. E. (2015): Chemical profiling of African guinea pepper fruit (*Xylopia aethiopica*) J. Med. Plant Herb *Ther. Res JMPHTR*, 3:10-15.

Oso, B. J., Oyeleke, O. M., Oladiji, A. T. (2018b): Inhibition of the Expressions of Splenic TNF-alpha Receptor Superfamily 8, CD3 and CD20 by Ethanolic Extract of *Xylopia aethiopica.* Int. J. Biol Sci and Appl 5(2): 29-33.

Oso, B. J., Oyewo, B. E., Oladiji, A. T. (2018a): Phytochemical composition, antioxidant capabilities and Immunomodulatory In vitro indices of *Xylopia aethiopica* fruit extracts. *Adv Pharm Journal.* 3(1): 29-37

Oso, B. J., Oyewo, E. B., Oladiji, A. T. (2017): Ethanolic, n-hexane and aqueous partitioned extracts of *Xylopia aethiopica* fruit modulated inflammatory responses in turpentine oil induced acute inflammation in male Wistar rats. *Int J Res Health Sci.* 5(2):1-10.

Santamaria, P., Elia, A., Serio, F., Todaro, E. (1999): A survey of nitrate and oxalate content in fresh vegetables. *Journal of the Science of Food and Agriculture.* 79: 1882–1888.

Sosulski, F. W., Humbert, E. S., Bui, E. S., Jones, J. I. (1976): Functional properties of rapeseed flours, concentrates and isolates. *J. Food Sci.* 41: 1349-1351.

Stroshine, R., Hamann, D. D. (1994): Physical properties of agricultural materials and food products," Course manual, Purdue University, USA.

Sweat, V. E. (1986): Thermal properties of foods, Macel Dekker Inc., New York.

Tchiegang, C., Mbougueng, D. (2005): Composition Chi- mique des Epices Utilisées dans la Préparation du na'a poh et du kui de l'Ouest Cameroun, Tropicultura. 23(4):193-200.

Yesilada, E., Bedir, E., Çalıs, I.¸ Takaishi, Y., Ohmoto, Y. (2005): Effects of triterpene saponins from *Astragalus* species on in vitro cytokine release. *Journal of Ethnopharmacology*. 96: 71–77.