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Characterization of domestic onion wastes and bulb (*Allium cepa* L.): fatty acids and metal contents

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Abstract

Different parts of onion bulb that constitute to waste were characterized for their nutritive value using standard methods. Proximate analysis of the samples revealed that protein (8.76%) and ash (11.46%) was highest in top-bottom part, carbohydrate (66.12%) in outer scale, fat (15.71%) and fiber (26.84%) was highest in outer scale part while highest amount of moisture (9.21%) was reported in top-bottom part. X-ray spectrometry revealed that the outer scale had the highest level of calcium (3.05%) followed by the onion bulb (2.98%) and least in the top-bottom part (2.08%). Gas chromatographic analysis of the extracted oil revealed that the oil from the outer scale part has the highest percentage of linoleic acid, 52.87%. The iodine value of the bulb oil, top-bottom oil and the outer scale oil were 143.35, 142.08 and 189.52 respectively. The properties of different parts of onion that go to waste revealed that they could be dietary sources of nutritive elements and essential fatty acids.

Introduction

Onions (*Allium cepa* L.) are the second most important horticultural crop worldwide, after tomatoes, with current annual production around 66 million tonnes. Over the past 10 years, onion production has increased by more than 25% (FAO, 2008; Benitez *et al*., 2011). Raw and cooked onions are consumed as young green plants or as bulbs. They are valued for their distinctive pungency and flavour which improve the taste of other foods. Onion either green or bulbs are used almost daily in every home and are essential ingredient in Nigerian diet (NIHORT, 1986). In some rural parts of northern Nigeria, dried fermented preparations from green leaves are used to flavour foods when fresh onions are not available. Large amount of onion wastes are produced by consumption of onion both domestically and industrially, making it necessary to search for their utilization. These wastes get decayed and add themselves to the soil causing odour and in some cases causing harm to the environment.

The main onion waste include onion skins, two outer fleshy scales and roots generated during industrial peeling and undersized malformed or damaged bulbs (Benitez *et al*., 2011). These wastes represent an environmental problem since onions wastes are not suitable for fodder in high concentration due to onion characteristic aroma and neither as an inorganic fertilizer because of the rapid development of phytogenetic agents (Waldron, 2001). Recent development has also shown that dogs, cats, guinea pigs and other animals should not be given onions in any form due to toxicity during digestion (Cope, 2005, Salgado *et al*., 2011). Hence there is a need to find other use for onion wastes. Several work had been done on onion wastes to gain knowledge of their dietary fiber component, sulphur content and phenolic content (Benitez *et al*., 2011) but reports are scanty on the nutritive mineral elements and fatty acids profile of the oil. The objective of this work is to analyze these parts of onions that constitute to waste for their nutraceutical values as food ingredient thus reducing its contribution to environmental pollution.

Materials and Methods

Yellow variant of onion (*Allium cepa* L) bulbs were purchased in “Waso”market Ogbomosho, Oyo state, Nigeria. From each onion purchased, three batches of samples were generated by cutting to obtain different sections similar to those generated in industrial and domestic peeling (Benitez *et al*., 2011). Top-bottom section was obtained by slicing off 5-10 mm of the top and bottom ends of the onions; dry outer scale of the bulb was obtained by peeling the

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bulb and the third sample was obtained by dicing the whole bulb. The samples were dried at temperature of 50°C and blended into fine powder using Marlex Excella electric blender. The three samples were stored in air tight containers prior to analysis.

Proximate analysis

The proximate constituents were determined on dried ground samples of yellow variant onions and the parts that constitute to waste according to the official methods of analysis of the AOAC (2003): moisture content by oven drying a 0.5 g test sample at 105°C to a constant weight (950.46B); ash content by igniting a 0.5 g test sample in a muffle furnace at 550°C until light grey ash results (920.153); crude protein content by the classical macro-Kjeldahl method (981.10); and lipid (crude) content by petroleum ether extraction using a Soxhlet apparatus (960.39) and carbohydrate was obtained by difference.

Quantification of mineral elements

The sample mineral elements were analysed using X-Ray fluorescence (XRF) transmission emission technique at the centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife, Nigeria, with model: PX2CR Power Supply and Amplifier for the XR-100CR Si Detector. The samples were pulverized, pelletized and then irradiated with X-Ray for 1000 s, to obtain the characteristics spectral, each spectral was made up of peaks which was characteristics of certain elements contained in the sample. The spectrum was checked on the computer system and then interpreted for quantitative determination of elements by direct comparison of count rates.

Determination of chemical properties of the oil

The oils were extracted with petroleum spirit (40-60°C boiling range, Sigma) using the Soxhlet extraction method. The chemical parameters were determined using AOAC 965.33, AOAC 920.158, AOAC 936.15, AOAC 933.08 for peroxide value, iodine value, saponification value and acid value respectively (AOAC, 1990).

Preparation of fatty acid methyl esters

A 50 mg of the extracted oil from the sample was esterified for five (5) minutes at 95°C with 3.4 ml of the 0.5M KOH in dry methanol. The mixture was neutralized by using 0.7M HCl and 3 ml of 14% boron triflouride in methanol. The mixture was heated for 5 minutes at the temperature of 90°C to achieve complete methylation process. The fatty acid methyl esters were thrice extracted from the mixture with redistilled n-hexane. The content was concentrated to 1 ml for gas chromatography analysis and 1 µl was injected into the injection port of GC. The fatty acids were identified by comparing their retention times with those of standards and the content of fatty acids was expressed as percentage of total fatty acids.

Fatty acids profile

The fatty acids profile was determined using gas chromatography equipped with a flame ionization detector and a 30 m x 0.25 m column coated with a 0.25 µm film of HP INNOWAX. Split injection (split ratio 20:1) was performed with nitrogen as carrier gas at a flow rate of 22 psi. The column temperature was maintained at 60°C for 1 min after injection then programmed at 12°C min^{-1} for 20 min to 250°C, held for 2 min, then at 15°C min^{-1} for 3 min held for 8 min. The injection port temperature was 250°C and detector temperature was 320°C.

Statistical analysis

The descriptive statistics (mean, standard error) were conducted using MS Office Excel 2007 (Microsoft, Redmond, Washington, USA).

Results and Discussion

Proximate constituents

The proximate composition of the yellow variant of onion bulb and its parts; top-bottom and outer scale were presented in Table 1. Moisture was determined on dry weight basis; the moisture content was highest in the top-bottom part and lowest in the outer scale. Thus, an increase was observed from inner bulb sections towards outer bulb sections. The crude protein content of the bulb 8.76 ± 0.70 g/100 g is comparable to that of the top-bottom part 8.75 ± 0.01 g/100 g and lowest in the outer scale part with 2.64 ± 0.01 g/100 g. The high content of crude protein in the top-bottom waste may be due to the fact that the growing apex of the onion is located in the bottom. Moreover, differences between bulb and outer scale was found suggesting that crude protein increases towards young scales and growing apex; this is in agreement with Jaime *et al*. (2002) who indicated that nitrogen compounds in bulb ripening were transported from senescence leaves to the bulb. The crude protein of the onion bulb 8.75 and top-bottom part 8.76 were higher than 7.00 ± 0.01% crude protein in a spice; *Syzygium aromaticum* (Bello and Jimoh, 2012). Although the level of protein in the different parts are lower than 12% calorific value of protein recommended for food to be a good source of protein (FNB, 2002), when combine with other food source it could be of high biological value.

The ash content was highest in the top-bottom

Table 1. Proximate composition of onion bulb and its parts (g/100 g) dry weight

Samples	Crude protein	Crude fiber	Crude fat	Ash content	Moisture content	Carbohydrate
Onion bulb	8.75±0.07	6.05±0.01	14.98±0.05	2.32± 0.07	8.78 ±0.01	65.16 ± 0.05
Top-bottom	8.76 ± 0.01	15.68±0.01	15.71±0.04	11.46±0.01	9.21 ±0.01	54.88 ±0.02
Outer scale	2.64 ±0.01	26.84 ±0.02	15.13±0.03	8.06 ±0.01	8.02 ±0.00	66.12 ±0.02

Means ± SD, n = 3

Table 2. Mineral composition of onion bulb and its parts g/100 g

Elements	Onion bulb	Top-bottom	Outer scale
Potassium	2.98 ±0.08	1.52 ±0.03	1.02 ±0.03
Calcium	1.22 ±0.05	2.08 ±0.03	3.05 ±0.05
Manganese	0.05 ±0.00	0.06 ±0.00	0.08 ±0.00
Iron	0.04 ± 0.00	1.33 ±0.00	1.00 ±0.00
Copper	0.13 ± 0.00	0.01±0.00	0.04±0.01
Zinc	-	0.09±0.02	0.03±0.01
Strontium	-	0.68±0.00	0.60±0.00
Titanium	-	0.09± 0.00	0.04±0.00
Chromium	-	7.90×10^{-6}	-
Nickel	-	-	5.6×10^{-6}

Means ± SD, n = 3, - : not detected

part 11.46 ± 0.01 g/100 g followed by the outer scale 8.06 ± 0.01 g/100 g and lowest in the bulb with 2.32 ± 0.07 g/100 g. This suggested the presence of high mineral content in the top-bottom part. The onion bulb and its parts contain appreciable amount of oil which could complement the one in the main meal when used as food ingredient. Fats are major energy source in human nutrition, ranking close behind carbohydrate. The outer scale contained the highest crude fiber 26.84 ± 0.02 g/100 g, top-bottom 15.68 ± 0.01 g/100 g and the bulb 6.05 ± 0.01 g/100 g. It has been reported that food fiber helps to prevent over-absorption of water and the formation of hard stools which can result in constipation. Besides, fiber lowers the body cholesterol level, thus, reducing the risk of cardiovascular diseases (Rumeza *et al.*, 2006) inclusion of the outer scale of onion in soup ingredient could be of health benefit.

Levels of mineral elements

Levels of mineral elements were presented in Table 2. Great variation exists in mineral content of onions among cultivars (Bibak *et al.*, 1998; Ariyama *et al*., 2007). Therefore, the mineral content determined in the onion bulb differs from those determined in Recas and Figueres cultivars (Benitez *et al*., 2011). The mineral distribution in onion wastes depend on the type of mineral found in the soil; the highest concentration of iron, zinc and strontium was found in top-bottom waste probably because this part comprise the plant roots in which the nutrient uptake occurs, whereas the highest concentrations of potassium and copper were found in the onion bulb.

Calcium was highest in the outer scale (3.05 g/100 g) followed by the top-bottom (2.08 g/100 g) and least in the bulb (1.22 g/100 g). Potassium content of the bulb, top-bottom and outer scale were 2.98 g/100 g, 1.52 g/100 g and 1.02 g/100 g respectively. Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins which helps to repair worn out tissues (Malik, 1982) and calcium is the major component of bone and helps in teeth development (Brody, 1994). Chromium is present only in the top-bottom waste and nickel is found only in the outer scale. Parman *et al.* (1993) showed that the medicinal values of some plant species used in homoepathic system may be due to the presence of Ca, Cr, Cu, Fe, Mg, K and Zn. According to Hooker (1987), chromium and zinc have important roles in the metabolism of cholesterol as well as heart diseases; their presence in plants may be correlated with therapeutic properties against diabetic and cardiovascular diseases. The manganese content of the top-bottom waste is comparable to that of *Morinda lucinda* (685 mg/kg) which has medicinal properties (Ajasa *et al.*, 2004). The wastes contain some transition metals which are essentially known for catalytic activities (Mn, Fe, Ni, Ti, Cr), and thus could be explored as food ingredient to improve digestion processes if added to food thereby aid and or increase metabolic activity in the body. The level of iron is highest in the top-bottom; Fe is the constituents of haemoglobin which is used in respiratory processes; incorporation of this part in food ingredients could assist in prevention of iron deficiency anaemia.

Fatty acids profiles

The fatty acids profile of the oils was reported in Table 3. Nine fatty acids were identified in the onion bulb and top-bottom part, five of which were saturated and four were unsaturated. Twelve fatty acids were identified in the outer scale part, six of which were saturated. The unsaturated fatty acids were predominant in the onion bulb with 51.6% of the total fatty acids; saturated fatty acids were predominant in the top-bottom waste with 50.43% of the total fatty acids. Unsaturated fatty acids were in higher quantity in the outer scale part with 76.79% of the total fatty acids. The total polyunsaturated fatty

Table 3. Fatty acid composition of the oil extracted from onion bulb and its parts (%)

Fatty acids	Carbon Number	Onion bulb	Top-bottom	Outer scale
Lauric acid	12:0	0.48	0.46	0.94
Myristic acid	14:0	1.59	1.34	1.28
Palmitic acid	16:0	41.20	41.52	9.80
Palmitoleic acid	16:1	0.15	0.30	2.84
Stearic acid	18:0	5.47	6.76	8.81
Oleic acid	18:1	36.5	38.67	17.57
Linoleic acid	18:2	12.65	10.50	52.87
Linolenic acid	18:3	0.85	0.08	2.88
Arachidic acid	20.0	0.67	0.35	0.59
Behenic acid	22:0	-	-	1.23
Erucic acid	22:1	-	-	0.63
Lignoceric acid	24:0			0.54
Total Saturated fatty acids		49.41	50.43	21.42
Total Unsaturated fatty acids		50.60	49.55	76.79

Table 4. Chemical characteristics of the oil extracted from onion bulb and its parts

Characteristics	Onion bulb	Top-bottom	Outer scale
Acid value (mg KOH g^{-1})	26.93±0.02	25.25± 0.04	15.71± 0.04
Peroxide value (meq /Kg)	6.00 ± 0.12	10.00 ± 0.15	14.00 ± 0.20
Saponification value (mg KOH/g)	316.96 ± 1.54	255.96 ±0.05	350.62±0.10
Iodine value (gI_2/100g)	143.35±0.83	142.08 ±0.05	189.52 ± 0.04

Means ± SD, n = 3

acids (PUFA) in the onion bulb 13.50% and that of the top-bottom part 10.56% compared favourably to that of palm oil 9% and the 55.75% PUFA in the outer scale part of onion is higher than 52% PUFA in cottonseed oil (Manasori, 2002).

The result showed that lauric acid was highest in outer scale while myristic acid was highest in onion bulb, the level of myristic acid in the outer scale compared favourably with the reported value of 1.23 myristic acid present in palm oil while both the bulb and top-bottom contained higher level of palmitic acid which is comparable to the 41.78% reported to be present in palm oil (Chowdhury *et al.*, 2007). The outer scale however had low level of palmitic acid. Incorporation of the outer scale as part of food ingredient might be an advantage, as consumption of high level of saturated fatty acids has been implicated in heart related diseases (Frank *et al.*, 2001; Griffin, 2008). The top-bottom oil have the highest percentage of oleic acid followed by the onion bulb, the outer scale oil had the lowest. Oleic acid (omega-9) is a monounsaturated fatty acid that had been reported to be beneficial in reducing the risk of cardiovascular diseases such as stroke, high blood pressure, angina pectoris (chest pain) and heart failure (Marlene, 2012).

Both linoleic acid and linolenic acid are detected in the oils; these are known as dietary essential fatty acids (EFA) that cannot be synthesized by humans (Paola *et al.*, 2004). Interestingly the outer scale that is usually discarded as waste contains 52.87% of linoleic acid. This part could therefore be a valuable dietary supplement for the high level of linoleic acid that has been reported to be one of the most important polyunsaturated fatty acids in human food because of its prevention of distinct heart vascular diseases (Boelhouwer, 1983). Behenic, erucic and lignoceric acids were not detected in both the bulb and top bottom but present in outer scale. Behenic acid was reported to have cholesterol - raising potential but only at high concentration. The cholesterol - raising potential of oil having low concentration of behenic acid is not significantly different from that of palm oil (Cater and Denke, 2001).Thus the level in the outer scale might not be of any health concern.

Chemical properties of the oil

Chemical properties are among the most important properties that determines the present condition of oil. Table 4 shows the result of the chemical characteristics of the extracted oil. The acid value of the oil from the onion bulb and its parts were high. This indicated that the oils might be unstable at room temperature (Falade *et al.*, 2008). Peroxide value is a measure of oxidation or rancidity of oil, values below 10 meq/Kg are characteristic of fresh oils while values between 20 and 40 mEq/Kg could result to rancid taste (Eka *et al.*, 2009). Peroxide value of the oil from the onion bulb (6 meq/Kg) was below 10 meq/Kg while the peroxide values of the parts were higher than 10 meq/Kg but lower than 20 meq/Kg. This indicated that the bulb oil can be kept for long without deterioration while those of the parts might be susceptible to rancidity. The saponification values of the oil from the onion bulb, top-bottom and outer scale wastes; 316.96, 255.26 and 350.62 respectively were higher than that of sunflower oil 188-194 mgKOH/g and that of soybeans 192.3 g KOH/kg (Falade *et al.*, 2008). These high values showed that the oils are not suitable for soap production as they will require high amount of KOH to saponify one gram of oil. Iodine value is the measure of unsaturation of the oil. Iodine value of outer scale oil was the highest 189.52; while that onion bulb oil 143.35 was higher than that of the top-bottom waste 142.08. The iodine value of the onion bulb oil and top-bottom part is comparable to that of sunflower oil 118-141, corn oil (103-128) and cotton seed oil (99-119) which are more suitable for use in the food industries (Noor and Ikram, 2009).

Conclusion

The results showed that each part that constitutes to waste is valuable. Thus, top-bottom could be a valuable source of protein, fat and nutritive elements while the outer scale could be a potential valuable source of dietary fibre and its oil an excellent source of essential fatty acids than the onion bulb consumed. Therefore, consumption of the parts that are discarded as waste as food ingredient will not only prevent environmental pollution but will increase appreciably the amount of nutrients available for body building.

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