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Evaluation of proximate, amino acid profile and oil characterisation of *Irvingia wombolu* fruit pulp and peel

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Abstract

The *Irvingia wombolu* fruit consists of pulp, peel and kernel. In Nigeria, the pulp and peel are usually allowed to rot, in order to obtain the kernel used in the preparation of a popular local draw soup. The present work was therefore aimed to determine the nutritional composition of *I. wombolu* pulp and peel for its potential as a source of human food and animal feed. The proximate, amino acid profile and oil characterisation of *I. wombolu* pulp and peel were carried out using standard methods. The peel contained higher protein (6.31%), fat (0.41%), ash (4.34%) and crude fibre (17.48%) than the pulp (4.73, 0.38, 2.7 and 6.89%, respectively). An appreciable amount of essential and non-essential amino acids were obtained with lysine found in highest abundance of 0.0192% and 0.0254% in pulp and peel, respectively. Prominent essential oils identified in the peel were δ-αtocopherol, squalene, β-tocopherol, while the pulp contained squalene and stigmasterol. The presence of essential amino acids; lysine and methionine in pulp and peel of *I. wombolu* indicate that it can serve as complementary in food and feed materials that lack the two amino acids. The essential oil profile also suggests its potential use in food, pharmaceuticals and cosmetics.

Introduction

Irvingia (family *Irvingiaceae*) consists of two major cultivars, namely *I. gabonensis* and *I. wombolu*, which are commonly known as the African mango, *dika* nut, bush mango or wild mango. Both cultivars originated in West and Central Africa (Lowe *et al.*, 2000; Atangana *et al.*, 2002). The fruit of either cultivar consists of pulp, peel and kernel. *I. gabonensis* has a sweet pulp, while the pulp of *I. wombolu* is bitter and has a taste similar to turpentine. However, its kernels are used in local food preparations (Leakey *et al.*, 1999).

The edible kernels are widely marketable and have various local names. In Cameroon, it is called '*etima*' (Ndoye *et al.*, 1997), while in Northern Gabon, it is called '*odika*' (Moss, 1995). In Nigeria, the powdered kernels of *I. wombolu* are cooked with leafy vegetables (Ekpe *et al.*, 2007), spices and other additives to make an assorted draw soup called '*ogbono*' (Igbo) or '*apon*' (Yoruba).

There are several reported methods for obtaining the kernels from *Irvingia* fruits. Ejiofor (1994) noted that, traditionally, the fruits are piled up in heaps and left to rot and ferment prior to extraction of the seed. Ladipo *et al.* (1996) reported that the seeds can either be taken out wet from the fermented fruits, or the fruits may be sun-dried as an alternative to fermentation. The fruits can be split open with a cutlass to reveal the hard seed inside (Ayuk *et al.*, 1999).

The composition of *I. wombolu* kernels have been well-studied (Ainge and Brown, 2001; Leakey *et al.*, 2005; Ekpe *et al.*, 2007), since they have been the most economically valuable part of an *Irvingia* tree. However, there is scarce information on the nutritional composition of the pulp and peel, which constitutes over 60% of the fruit.

In view of this, there is a need to evaluate the chemical composition of the pulp and peel of *I. wombolu* for its probable potential usage as food, feed, cosmetics and pharmaceutical purposes.

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Materials and methods

Irvinga wombolu fruit (var. *Excelsa*) (Harris, 1996) was obtained from the indigenous orchard of the Fruit Research Programme, National Horticultural Research Institute (NIHORT), Ibadan, Oyo State, Nigeria. The fruit was authenticated by an agronomic and seed expert, Dr. Abdul-Rafiu A. M. of Seed Technology Unit, Vegetable and Floriculture Department, National Horticultural Research Institute, Ibadan, Oyo State, Nigeria. The fruits were washed, air-dried and stored in well-aerated fruit crates.

Sample preparation

The fruits were washed, air-dried and separated into pulp, peel and kernel with a knife, and dried at 52 ± 1°C in a food dehydrator (Excalibur, Model 4926T USA).

Sample analysis

A proximate analysis was carried out on the pulp and peel following the AOAC (2005) methods. The solvent extraction method was used to extract the oil. The identification of the compounds present in the oil extract was performed on a model 597 system chromatograph, equipped with a model 7890 mass selective detector (Agilent Technologies), following the methods described by Hussain and Maqbool (2014).

The amino acid profile of the pulp and peel was analysed by the spectrophotometric method (Friedman, 2004) using ninhydrin chemical reaction, on a 752 W uv-vis Grating spectrophotometer. The data collected were subjected to the analysis of variance (ANOVA) and mean, separated accordingly at a probability of < 0.05, using the SAS 2000 software.

Table 1: Proximate composition of *Irvingia wombolu* peel and pulp (%).

Irvingia wombolu	Moisture	CP	Fat	Ash	Fibre	NFE
Peel	7.40[b]	6.31[a]	0.41[a]	4.34[a]	17.48[a]	64.06[b]
Pulp	9.20[a]	4.73[b]	0.38[a]	2.70[b]	6.89[b]	76.10[a]

NFE: Nitrogen Free Extract, CP: Crude Protein.

Different superscript letters in the same columns indicate statistically significant difference between pulp and peel at $p < 0.05$.

Results

There was a variation in the proximate composition of the pulp and peel, with the peel having a higher value of protein (6.31%), fat (0.41%), ash (4.34%), and crude fibre (17.48%), as compared to those of the pulp (Table 1). The pulp had a higher moisture content (9.20%) and nitrogen-free extract (NFE; 76.10%).

The essential oil yield of peel was 0.78%, while the pulp yielded 0.87% on a dry weight basis. The oil characterisation identified 19 and 26 essential oils from the peel and pulp, respectively (Table 2).

The total amino acid content of the pulp and peel of *I. wombolu* was 0.150 and 0.145/g protein respectively (Table 2).The amino acid profile showed a higher level of asparagine, alanine, aspartic acid, cysteine, hystidine, lysine, methionine, phenylalanine, proline, serine, tyrosine and valine in the peel than in the pulp (Table 3). Lysine was the most abundant amino acid in both the pulp and peel at 0.0192% and 0.0254%, respectively. The Hen's egg scoring pattern and chemical score of pulp and peel of *I. wombolu* are presented in Table 3.

Table 2: Amino acid in pulp and peel of *lrvingia wombolu.*

Amino acid	Pulp (%)	Peel (%)
Asparagine	0.0034[b]	0.0039[a]
Alanine	0.0107[b]	0.0109[a]
Aspartic acid	0.0060[b]	0.0097[a]
Cysteine	0.0043[b]	0.0046[a]
Glutamic acid	0.0041[a]	0.0024[b]
Glycine	0.0088[a]	0.0086[b]
Histidine	0.0187[b]	0.0202[a]
Isoleucine	0.0105[a]	0.0028[b]
Leucine	0.0108[a]	0.0045[b]
Lysine	0.0191[b]	0.0254[a]
Methionine	0.0059[b]	0.0074[a]
Phenylalanine	0.0063[b]	0.0121[a]
Proline	0.0008[b]	0.0059[a]
Serine	0.0009[b]	0.0089[a]
Threonine	0.0088[a]	0.0018[b]
Tyrosine	0.0035[b]	0.0047[a]
Tryptophan	0.0111[a]	0.0038[b]
Valine	0.0074[b]	0.0078[a]
Total	0.1495	0.1454

Different superscript letters between columns indicate statistically significant difference between amino acid in pulp and peel at $p < 0.05$.

Discussion

The protein content in the pulp and peel at 4.73% and 6.31% was high when compared with the 2.38% obtained by Oluwole *et al.* (2013) for the ripe pulp of avocado and 6% obtained by Sarkiyayi *et al.* (2013) for the big-seeded Durshea variety of *Mangifera indica*. The protein content suggests that the pulp and peel could be combined with other ingredients in the diet of both humans and animals.

Table 3. Essential amino acids Whole Hen's scoring pattern and chemical score for pulp and peel of *Irvingia wombolu*.

Amino Acid	Whole Hen's Scoring Pattern			Chemical Score		
	Standard	Pulp	Peel	Standard	Pulp	Peel
Lysine	6.20	3.08×10^{-3}	4.10×10^{-3}	55	3.47×10^{-3}	4.62×10^{-3}
Leucine	8.30	1.30×10^{-3}	5.42×10^{-3}	70	1.54×10^{-3}	6.42×10^{-4}
Threonine	5.10	1.73×10^{-3}	3.52×10^{-3}	40	2.20×10^{-3}	4.50×10^{-4}
Isoleucine	5.60	1.88×10^{-3}	4.54×10^{-3}	40	2.63×10^{-3}	7.00×10^{-4}
Methionine	3.20	1.84×10^{-3}	2.30×10^{-3}	35	1.69×10^{-3}	2.11×10^{-3}
Phenylalanine	5.10	1.29×10^{-3}	2.37×10^{-3}	60	1.05×10^{-3}	2.02×10^{-3}
Valine	7.50	9.86×10^{-4}	1.04×10^{-3}	50	1.48×10^{-3}	1.56×10^{-3}

The crude fat was low as compared to the 13.01% obtained in the Congo mango (Nzikou *et al.*, 2010). Fats, which consist of essential fatty acids (EFA), have been shown to enhance the taste and acceptability of foods, slow gastric emptying and intestinal motility, thereby prolonging the satiety and facilitating the absorption of lipid-soluble vitamins (FAO, 2010). Fat plays a significant role in the shelf life of food and food products. Low fat delays the rancidity of food.

The crude fibre value of 17.48% found in the peel was higher than the range of 0.8-6.29% reported for most tropical plant seeds in Africa (Akpambang *et al.*, 2008). Also, Akpabio (2012) reported 3.11% crude fibre value for almond seeds. High fibre content aids the digestive system in mammals.

The NFE values of 64.06% and 76.10% found in peel and pulp, respectively, were quite high and as such, could be used as dietary supplements for people who require a lot of energy for daily activities, such as athletes. Also, the high NFE suggests that *I. wombolu* can be used as a carbohydrate base to replace maize (which is in high competition between humans and animals) in animal feed as a source of energy (Shaahu *et al.*, 2017).

Protein is a macronutrient of major importance in nutrition, and nature's most functionally diverse biomolecules. Plant and animal proteins are composed of more than 20 individual amino acids. Within the body, amino acids are used for building of variety of structural proteins and enzymes. Muscle tissues, skin, hair, fingernails and enzymes are all composed of amino acids (Kliegman *et al.*, 2007). They serve as a source of energy, carbon and nitrogen.

The total amino acid content of the pulp and peel of *I. wombulu* was 0.150 and 0.145 per gram protein respectively (Table 3). Pulp was found to contain higher total amino acids than peel. These results are lower than those reported for *I. gabonensis* (Niyi, 2014), but the values are similar to those obtained by Ismail *et al.* (2013) for protein and amino acid of various eggs available in Malaysian local markets.

The Hen's egg scoring pattern and chemical score of pulp and peel of *I. wombulu* is presented in Table 4. Lysine yielded the highest concentration for pulp, while phenylalanine was highest in peel. Both essential amino acid (EAA) and non-essential amino acid (NEAA) were present in various concentrations in both pulp and peel. From the hen's egg scoring pattern of EAA, lysine was the highest while valine was the lowest amino acid in the pulp. However, in the peel, isoleucine was the highest while threonine was the lowest amino acid.

The presence of lysine, which is an essential amino acid, indicates that both pulp and peel have an advantage over wheat and maize which are deficient in human foods and animal feeds (Häffner *et al.*, 2000). The quantity present, of all EAAs' in their various concentrations, suggest its fair source of the nutrients. Results from the analysis in the present work show that the consumption of the fruit as source of lysine could be recommended to fulfil the adult daily requirement as stated by WHO and FAO (1991). *Irvingia wombolu* pulp and peel contained appreciable levels of methionine and lysine, hence can be incorporated into poultry diets to reduce the cost of animal feed production. Also, the incorporation of the *I. wombolu* pulp and peel in human food will increase the protein intake, which will help to meet the body's demand for amino acids and enhance the flow through required metabolic pathways to maintain optimum body structure and function (Stadlmayr *et al.*, 2013).

The three most important essential oils identified in the analysis of the pulp and peel (Figure 1 and 2) were friedelan-3-one (anti-inflammatory), stigmasterol (anti-tumour, anti-cholesterol), and beta-sitosterol (anti-cholesterol, lowering the risk of heart disease, boosting the immune system, and prevention of colon cancer) (Johnsson and Dutta, 2003). The results obtained in the present work are similar to that of Bortolomeazzi *et al.* (1999). Hentriacontane is used as a food additive i.e. thickener and carrier (Schmidt *et al.*, 2014). Phytol (which is also a food additive but known for its anti-schistosomal

Table 4. Oil constituents and abundance in the peel and pulp of *Irvingia wombolu*.

Oil constituent in peel	Abundance (%)	Oil constituent in pulp	Abundance (%)
1,3-Cyclohexadiene	1.725	Friedelan-3-one	4.539
Cyclotetradecane	1.445	Benzisothiazol-3-amine	3.367
Neophytadiene	2.949	γ-sitosterol	3.843
Dimethyl-cycloct-4-enone	2.369	β-Sitosterol	5.346
1-Octadecene	2.486	Stigmasterol	6.971
Octadecadienoic acid methylester	0.084	5-Cholestene	6.634
Linoelaidic acid	1.779	δ-α-Tocopherol	3.368
Octadecadienoic acid	1.144	Hentriacontane	4.764
Bis(2-ethylhexyl) phthalate	2.367	β-Tocopherol	7.958
Squalene	12.217	2-Ethylacridine	2.512
Dipyrrylmethane	3.044	Oxirane	0.09
Oxybenzylideneacetophenone	2.772	Nonacosane	1.615
Benzo(h)quinolone	4.387	Squalene	10.015
β-Tocopherol	10.761	1,3-Benzenedicarboxylic acid	1.026
2-hydroxyethylmethylamide	3.459	1H-indole-2-methyl-3-phenyl	1.185
δ-αTocopherol	25.507	1H-indole-5-methyl-2-phenyl	2.704
Stigmasta-3,5-diene	9.965	Bis(2-ethylhexyl)phthalate	4.822
Benzisothiazol-3-amine	4.873	2-Propenoic acid	1.919
Triazolidine-3-one	3.776	9,12-Octadecadienoic acid	0.136
		Phytol	2.927
		3-Eicosene	0.963
		Dibutylphthalate	1.138
		1,3-cyclohexadiene	3.384
		Benzene	1.185
		2-Propenoic acid-3-phenyl methylester	1.136
		β-Tocopherol O-methyl	1.820

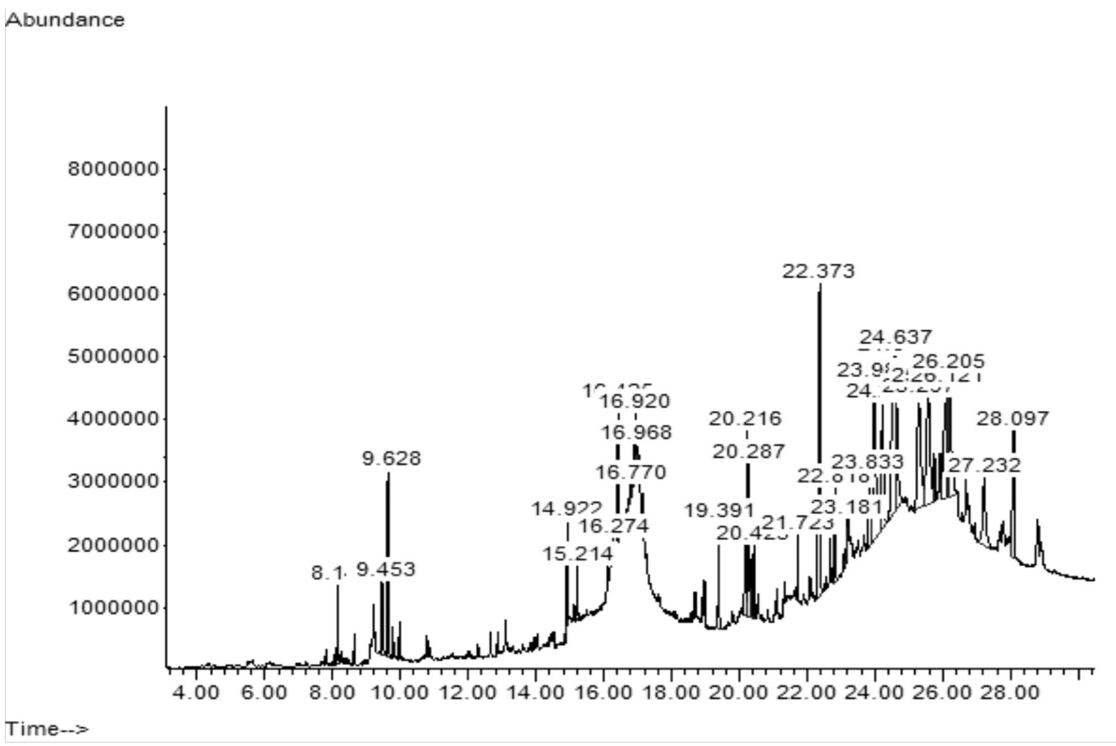

Figure 1: Oil characterisation of *Irvingia wombolu* peel (Abundance/min).

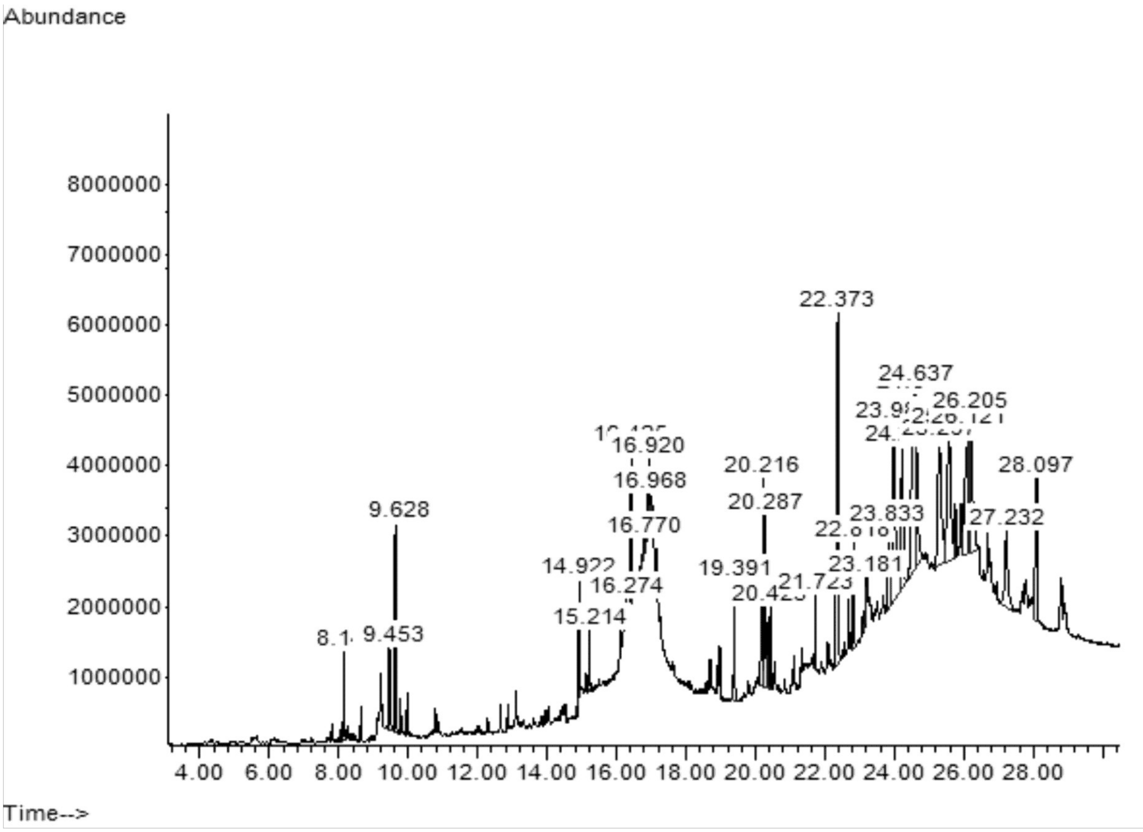

Figure 2: Oil characterisation of *lrvingia wombolu* pulp (Abundance/min).

properties) activates enzymes which have a positive effect on the production of insulin in the human body. Essential fatty acids play important roles in the life and death of cardiac cells (Reiffel and McDonald, 2006).

Many essential oils are used as raw materials in different fields, including cosmetics, phytotherapy, aromatherapy, nutrition and perfumes (Prasad *et al.*, 2011). For example, 1,3-cyclohexadiene, a side chain in zingeberene, helps in fighting infections caused by viruses and also protects against ulcers caused by stomach gas. It also limits the formation of plaques in Alzheimer's diseases (Nahar and Sarker, 2007). Neophytadiene acts as an anti-inflammatory agent, has acne-reducing properties and is also used as an additive in liquid cigarettes. Linoelaidic acid is an omega-6 fatty acid used in the biosynthesis of cell membranes, treatment of diabetes, cancer and obesity. Benzisothiazol-3-amine is an edible fatty acid, essential for human growth and development, treatment of atherosclerosis, skin cancer, migraines, and the reduction of the risk of heart disease (Nenseter *et al.*, 1994). Squalene, known for its use in the treatment of cancer, enhances the human immunity system, and is also used in treatment of arthritis and infections (Strychar *et al.*, 2003).

In the case of β-tocopherol and δ-αtocopherol essential oils, their administration has been reported to maintain healthy cells, improve eyesight, gout, arthritis, decrease blood clotting, menstrual migraines and muscular dystrophy (Jomova *et al.*, 2010). 5,5-di(ethoxy-carbonyl)-3,3-dimethyl1-4,4-dipropyl-2,2-dipyrrylmethane acts as an antioxidant with hypocholesterolemic, nematicide, pesticide, lubricant, anti-androgenic and haemolytic properties. 10,13-octadecadienoic acid methyl ester, also known as linoleic acid, is beneficial to the skin as it aids moisture retention. 9,12-octadecadienoic acid, also known as alpha-linolenic acid, is necessary for human growth and development, prevention of heart diseases and high blood pressure (Djilani and Dicko, 2012).

Conclusion

The evaluation of the pulp and peel of *I. wombolu* in the present work revealed that it is rich in protein and oil. Prominent essential oils have thus been identified. The presence of essential amino acids; lysine and methionine, indicate that it can serve as a complement in food and feed materials that are limited in the two amino acids. The presence of tocopherol and squalene in the pulp and peel of *I. wombulu* oils suggest their potential use in food, pharmaceuticals and cosmetics.

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