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Proximate Composition and Fatty Acid Profiles of Two Edible Leafy Vegetables in Nigeria

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Abstract: The proximate compositions and fatty acid contents of Amaranthus hybridus and Corchorus olitorius, two edible leafy vegetables in Nigeria, have been determined. The moisture, crude fat, crude fibre, crude protein and carbohydrate contents for A. hybridus were 85.40, 1.05, 2.36, 4.30 and 5.54% respectively, and those for C. olitorius were 85.35, 1.20, 2.60, 5.24 and 3.46% respectively. The energy values were 203.92 and 190.53 kJ/100g for A. hybridus and C. olitorius respectively. The main saturated fatty acids in the two vegetable oils were capric, lauric, palmitic and stearic acids, while oleic, linoleic, linolenic and arachidonic acids dominated the unsaturated ones. The total saturated fatty acids were 31.19% in C. olitorius and 35.18% in A. hybridus, while the total unsaturated were 64.82% in A. hybridus and 68.81% in C. olitorius. There were significant levels of total poly-unsaturated fatty acids as well as the two essential fatty acids, linoleic and ∞-linolenic acids in both samples, making them to be very beneficial to the consumer.

Keywords: Leafy Vegetables, Proximate Composition, Fatty Acid Profiles, Amaranthus Hybridus, Corchorus Olitorius

1. Introduction

Vegetables are the fresh edible portions of herbaceous plants which are either eaten raw (e. g. salad) or cooked [1]. They play a major contribution to the diet of an average Nigerian, especially in the southern area where a variety of the vegetables are readily available and affordable. Because they are very cheap, they are the toast of the poor and the down trodden and especially farmers who do not need to invest their hard-earned resources on vegetables but just harvest whatever variety of choice directly from their farms. In Nigeria and in most other tropical countries of Africa where the diet is mainly starchy foods, vegetables are the cheapest and most readily available sources of important proteins, vitamins, minerals and fibre. They increase variety and add flavour to diets and are a reasonable component of most meals [2].

They contain valuable food ingredients which are used as energy sources for body building, and as regulatory and protective materials [3]. They also act as buffering agents for acidic substances produced during the digestion process. They have low calorific values and negligible quantities of utilizable energy. Hence, they are ideal for the obese who can satisfy their appetite without consuming much carbohydrate. Furthermore, the percentage concentration of protein is low but what is present is of the high grade, while the quantity of vitamin E in leafy vegetables increases with their greenness. Leafy vegetables are used as laxative and as purgative to treat indigestion. The dark green leaves, just like the deep yellow fruits, provide a high amount of carotene, ascorbic acid and micro-minerals which play important roles in nutrient metabolism and slowing down of degenerative diseases [4]. Health disorders such as appendicitis, haemorrhoids, gallstones, heart diseases, obesity and constipation can either be corrected or treated by copious consumption of vegetables [5]. Some other leafy vegetables, apart from being used as purgatives, also serve as remedies for kidney disorder, hic-cups and as anthelmintic and antiasthmatic [6]. High vegetable diets are reported to have an ameliorating effect on the blood pressure of hypertensive patients and lowers systolic and diastolic blood pressure, blood viscosity and plasma fibrinogen [7]. The anti-oxidants present in vegetables prevent the potential cancer-inducing oxidative damage caused by reactive oxygen species such as free radicals that are generated in the body [8].

The determination of fatty acids in edible vegetable oils is

very essential to evaluate the suitability for their different uses in the diet, for food quality control and in the food industry. Being alternative sources of plant food, there is the need to evaluate the vegetables as sources of food for man and other uses, including industrial application. So far, there has been a dearth of information on fatty acid profiles of leafy vegetables in Nigeria and little or nothing has been reported on these two vegetables. This work was therefore carried out to ascertain the proximate composition and fatty acid profiles of Amaranthus hybridus and Corchorus olitorius, two of the commonly consumed leafy vegetables in Nigeria.

2. Materials and Methods

2.1. Sample Collection and Preparation

Fresh samples of the two vegetables were obtained from a local (Akinola) market in Ipetumodu, a town in Ife North Local Government area of Osun State, Nigeria. The market is noted for fresh farm produce. Each fresh sample was stored in a large polythene bag as soon as purchased and transported to the laboratory within the shortest time possible for immediate processing. About 1kg of each vegetable sample was washed in clean portable water to remove unwanted matter, cut into small pieces and oven-dried at 60°C. Each dried sample was ground into a fine powder and stored in a polythene bag in a refrigerator, ready for analysis.

2.2. Sample Treatment

The AOAC method was used for proximate analysis [9]. Available carbohydrates were calculated by difference. Calorific values were calculated using the following formula: Calorific value: (% proteins x 2.44) + (% carbohydrates x 3.57) + (% lipids x 8.37) [10]. Solutions of the vegetables were prepared for metal analysis by dry–ashing the sample at 550°C in a muffle furnace and dissolving the ash in 10% HNO_3, warming and filtering it into a 100ml standard flask and using distilled de-ionized water to make it up. Sodium and potassium were determined from the resulting solution by flame photometry and the other metals by using the Atomic Absorption Spectrophotometer (AAS). The results were compared with absorption of standards of these metals. Sampling and analyses were carried out in triplicates on each sample.

3. Results and Discussion

3.1. Proximate Composition

The results of the proximate composition of the two edible leafy vegetables in Nigeria are shown in Table 1. The moisture contents were 85.40% for Amaranthus hybridus and 86.35% for Corchorus olitorius. These values are comparable to those of four leafy vegetables in Southern Nigeria (Corchorus olitorius, Ocimum gratissimum, Talinum triangulare and Telfaria occidentalis) with value ranges of 79.98% and 89.47%, [3] in the range of those reported for some leafy vegetables in Southwest of Nigeria with values ranging between 75% in Solanum aethiopicum and 91.5% in Talinum triangulare [11] and also those of C. crepidioides (85.08%) and Solanum biafrae (87.5%) [12]. Variation in the compositions of the same food type from different sources may be due to the location, soil, variety, maturity and the cultural practices adopted during planting [13]. Some of the differences in the percentage composition might be linked to factors like location, climate, species, soil type, growing conditions, application of natural or artificial manure and the period of analysis [13, 14]. The high moisture contents of the vegetables are indicative of their freshness, making them to aid digestion of food better. But the high moisture contents also facilitate bacterial action on them, giving them a very short shelf life and easy perishability [2]. Water is clearly the most important nutrient and the most abundant substance in the human body. It comprises about three quarters of the human mass and is a major component in every cell. In addition water is needed to separate (by a process called hydrolysis) a phosphate group from adenosine triphosphate (ATP) or guanosine triphosphate (GTP) to get energy [15]. It is also the containing medium for electrolytes and all other ions throughout the human body.

Table 1. *Proximate compositions of Amaranthus hybridus and Corchorus olitorius, (g/100g fresh weight).*

Parameter*	Amaranthus hybridus (%)	Corchorus olitorius (%)
Moisture	85.40±0.36	86.35±0.36
Ash	1.35±0.14	1.15±0.11
Crude fat	1.05±0.22	1.20±0.17
Crude protein	4.30±0.79	5.24±0.32
Crude fibre	2.36±0.62	2.60±0.18
Carbohydrate	5.54±0.16	3.46±0.54
Energy values (KJ)	203.92±0.79	190.53±0.56

*Average of three determinations.

The two vegetable samples had low crude protein contents, being lower in A. hybridus (4.30%) and higher in C. olitorius (5.24%). These values are comparable to those of some vegetables reported by Adeniyi et al. from Edo State in southern Nigeria, ranging from 2.20% to 6.21%, within the range of 2.5–6.4% reported by Olaiya and Adebisi for 10 green leafy vegetables in the southwest of Nigeria, and those reported by Ajala Lola in Owo in the southwest of Nigeria for S. biafrae (4.03%) and S. nigrum (4.63%) respectively [3; 11; 16]. They are, however, higher than the values of 1.2% and 1.93% reported in Nigeria for Launea tetraxidioide and Basella rubra respectively, those got for O. gratissimum (3.4%) and C. esculenta (3.0%) from Ibadan, and those for S. nodiflorum (3.31%) and S. biafrae (3.03%) from Iree, both in the southwest of Nigeria (Isa et al., 2006; Adepoju and Oyewole, 2008; Adeleke and Abiodun, 2010) [2, 13, 17]. They are also higher than those reported by Omale and Ugwu for 27 vegetables from Kogi State in the middle belt of Nigeria with values ranging between 0.15% and 2.57% [18].

Protein is nutritionally significant in food as a source of amino acids in the diet of man, and also plays a part in the organoleptic properties of foods [19]. It is an essential food content without which our bodies would be unable to repair, regulate or protect itself. Essential body processes such as water balancing, nutrient transport and muscle contractions require protein to function properly, while it is also required for the formation of enzymes and hormones. It also aids in the formation of antibodies that enable the body to fight infection [20]. As a corollary, protein deficiency causes growth retardation, muscle wasting, oedema, abnormal swelling of the belly etc. [21]. The appreciable amount of protein in the vegetables indicates that the vegetables can be used for building and repairing of body tissues, regulation of body processes and formation of enzymes and hormones, and produce antibodies that enable the body to fight infection. Proteins serve as a major energy supplier [20].

The crude fibre contents gave 2.36% for A. hybridus and 2.60% for C. olitorius. These values are higher than those reported in Iree by Adeleke and Abiodun for S. nodiflorum (0.78%) and S. biafrae (0.92%), those reported in Owo by Ajala for S. biafrae (1.05%) and S. nigrum (1.13%), and the ones reported in Okada, Edo State of Nigeria for four leafy vegetables ranging from 0.21% to 0.33% [3, 13, 16]. They are, however, much lower than 17.78% reported for dry Senecio biafrae leaves from Ado-Ekiti [22]. Crude fibre plays an important role in the maintenance of internal distension for a normal peristaltic movement of the intestinal tract [23]. The substantial amount of fibre in these vegetables shows that they can help in keeping the digestive system healthy and functioning properly. Fibre aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up and lead to several diseases. It is involved in preventing colon cancer and constipation [24]. Furthermore, dietary fibre decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, which is an important factor in the management of diabetes. Dietary fibre also functions in the protection against cardiovascular disease, colorectal cancer and obesity [25]. To summarise, therefore, dietary fibre helps to lower the risk of coronary heart diseases, hypertension, diabetes, colon and breast cancer, piles and appendicitis [18].

The fat contents for the two leafy vegetables were very low, with values of 1.05% in A. hybridus and 1.2% in C. olitorius. These values are slightly higher than the values of less than 1.00% reported in some other studies in Nigeria but lower than those of four leafy vegetables from Edo State, Nigeria [2, 3, 11, 13]. The very low fat contents of the vegetables could be advantageous for individuals suffering from obesity and other related diseases. Indeed, a diet providing 1–2% of its calorific energy from fat is sufficient in human beings as excessive consumption has been implicated in certain cardiovascular disorders, such as atherosclerosis, cancer and aging. Health disorders such as appendicitis, haemorrhoids, gallstones, heart diseases and constipation are either corrected or treated by copious consumption of vegetables because of the low fat contents [5].

The two vegetables had low carbohydrate contents of 3.46% for C. olitorius and 5.54% for A. hybridus. These values are similar to some other reports elsewhere including those of Adeniyi et al., [3] with values for four leafy vegetables ranging between 3.17% and 6.25%. The low carbohydrate contents are a common phenomenon with leafy vegetables. Because they also have low fat and protein contents, they contribute very little to the energy values of meals. Hence, the leafy vegetables are ideal for the obese and diabetics who can satisfy their appetites without consuming much carbohydrate and, at the same time, control their weight and health.

3.2. Fatty Acid Profiles

The percentage fatty acid compositions of the oils of the two leafy vegetables are presented in Table 2. The most abundant saturated fatty acids in both samples included capric, lauric, palmitic and stearic acids, while oleic, linoleic, linolenic and arachidonic acids were the most abundant unsaturated ones. The order of abundance of the fatty acids is linoleic > oleic > stearic > lauric > arachidonic > linolenic acids in both samples. The linolenic acid contents of these vegetables are significant and compared well with those of citrus seed oils [26]. The oils had high degrees of unsaturation with percentages of 64.82% in A. hybridus and 68.81% in C. olitorius. Their high degrees of unsaturation reduce the probability of aiding heart diseases [27]. The significant levels of linoleic and linolenic acids in both samples are of nutritional importance. These are essential fatty acids, which cannot be synthesized in the body and have to be supplied from food for their essential roles in the body. They play a natural preventive role in cardiovascular diseases and promote the reduction of both total and high density lipoprotein cholesterol. Inappropriate balance of essential fatty acids contributes to various kinds of malfunctioning while a proper balance maintains and even improves health [28]. There are good amounts of these essential fatty acids in both samples, making them to be beneficial to the consumer. The nutritional importance of these oils is further buttressed by the linoleic acid (LA) and α-linolenic acid (ALA) ratios that fell within the WHO/FAO recommended ratio of between 5:1 and 10:1 [29]. The ratio of total unsaturated to total saturated fatty acids [TUSFA/TSFA or (P/S ratio)] was 1.84 in A. hybridus and 2.20 in C. olitorius. This ratio determines the detrimental effects of dietary fats. The higher the P/S ratio, the more nutritionally useful the oil is. This is because the severity of arteriosclerosis is closely associated with the proportion of the total energy supplied by saturated fats and polyunsaturated fats [14; 30].

The values here obtained compared favourably well with values reported for some other plant seed oils [14; 31]. The oleic/linoleic (O/L) ratio has to do with the stability and potentiality of the oil for deep frying [32]. The low values got for these oil samples may not be favourable for this purpose.

The high percentage of polyunsaturated fatty acids in the oil samples may be an advantage as these fatty acids are essential in the diets of man.

Table 2. *Percentage fatty acid profiles of Amaranthus hybridus and Corchorus olitorius.*

Fatty a cid %	Amaranthus hybridus	Corchorus olitorius
Caproic, C6:0	1.18	1.82
Caprylic, C8:0	3.50	1.86
Capric, C10:0	3.26	2.94
Lauric, C12:0	8.65	9.20
Myristic, C14:0	2.32	1.80
Palmitic, C16:0,	4.46	2.11
Palmitoleic, C16:1	0.14	0.23
Stearic, C18:0	10.30	10.10
Oleic, C18:1	22.20	19.92
Linoleic, C18:2	33.44	37.32
Linolenic, C18:3	4.79	5.90
Arachidic, C20:0	1.30	1.05
Arachidonic, C20:4	4.90	7.91
Behenic, C22:0	0.04	0.09
Erucic, C22:1	0.38	0.67
Lignoceric, C24:0	0.17	0.22
Total saturated	35.18	31.19
Total unsaturated	64.82	68.81
Total mono-unsaturated	22.72	20.82
Total poly-unsaturated	42.10	47.99
Essential fatty acids	38.23	43.22
P/S index	1.84	2.20
Oleic/linoleic Ratio	0.66	0.53
Linoleic/linolenic (LA/ALA) ratio	6.98	6.33

The presence of caprylic and capric acids in the leaves oils makes them useful in the commercial production of esters used in perfumes. Caprylic acid is also used in the treatment of some bacterial infections, because, due to its relatively short chain length, it has no difficulty in penetrating fatty cell wall membranes [33]. Capric acid is also used in the manufacture of lubricants, greases, rubber, dyes, plastics, food additives and pharmaceuticals [34]. Lauric acid is believed to have antimicrobial properties [24, 35]. It can undergo β-oxidation to produce energy and also be stored in adipose tissues [36]. Myristic acid is a common saturated fatty acid used in cosmetic. Palmitic acid is the first fatty acid produced during fatty acid synthesis and from which longer fatty acids can be synthesized [21, 24]. Palmitoleic acid plays an important role in increasing insulin sensitivity by suppressing inflammation, as well as inhibiting the destruction of insulin-secreting pancreatic beta cells, which make it useful for a diabetic patient (especially for type 2 diabetes mellitus). Oleic acid, a mono-unsaturated fatty acid, is associated with decrease in low-density lipoprotein (LDL) cholesterol, and possibly increase in high-density lipoprotein (HDL) cholesterol [37]. The reasonable level of linolenic acid in these vegetables is of nutritional importance. It is an essential polyunsaturated fatty acid used in the biosynthesis of arachidonic acid (AA) and thus some prostaglandins [36]. They are required for cell growth and maintenance. The significant levels of arachidonic acid in these vegetables are also of dietary importance as it serves as a precursor of prostaglandin and thromboxane biosynthesis [38]. Behenic acid (docosanoic acid) found in the sample is a normal carboxylic acid while the presence of erucic acid which is a monounsaturated omega-9 fatty acid makes the sample useful as a precursor in bio-diesel fuel production [34]. Although the content of fatty acids in vegetables is rather low because of the low oil contents, they still represent an important nutritional factor, which will be especially important in vegetarian populations.

4. Conclusion

This study has reported the proximate composition and fatty acid contents of A. hybridus and C olitorius, two edible vegetables in Nigeria. Even though they contained low oil contents, the high levels of unsaturated fatty acids in the vegetable oils reduce their probability of aiding heart diseases. The ease of availability and their readily affordable nature, make them a good source of essential fatty acids needed for good and healthy living of the consumers, especially the low income group. Their cultivation and consumption should therefore be encouraged.

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