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Proximate composition and fatty acid profile of garden egg (*Solanum aethiopicum* L) fruit

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Abstract
The physicochemical properties of the fruit and the fatty acid profile of the fruit oil of garden egg - Solanum aethiopicum - have been determined using standard methods of the AOAC. The proximate composition gave dry matter 9.07% and moisture 90.89%, ash content 1.52%, crude fat 0.85%, crude protein 1.783%, crude fibre 2.29% and carbohydrate 2.63%. The predominant saturated fatty acids were palmitic (20.71) %, stearic (9.019) %, lauric (7.2) % and myristic (4.7%), while oleic (10.77%), linoleic (32.65%), arachidonic (4.64%) and linolenic (3.173%) acids dominated the unsaturated ones. The most abundant fatty acids in the order of abundance were linoleic > palmitic > oleic > stearic > lauric > myristic > arachidonic > linolenic acid. The total unsaturated fatty acids (56.492%) predominated the total saturated (43.508%), while the percentage poly-unsaturated (40.462%) was greater than that of mono-unsaturated (16.034%). The high level of essential fatty acids in the fruit oil is an advantage, bearing in mind that they cannot be produced in the body, but are needed and must be supplied from the food consumed for the necessary functions for which they are needed in the body. The good total unsaturated/saturated (or PS) ratio makes the fruit oil nutritionally very useful to be adopted for domestic purposes.

Keywords: African garden egg; *solanum aethiopicum*; fruit oil; proximate composition; fatty acid profile

1. Introduction

Edible fruits and nuts of different variations are commonly found in West Africa and some tropical countries of the world, particularly in Nigeria. One of such edible fruits is the Solanum species. Solanum is a widespread plant genus of the family Solanaceae, having over 1000 species worldwide of which about 100 species are indigenous to Africa [1]. The Solanum species include a number of edible crop plants and some poisonous ones. About 25 species are found in Nigeria, including those with edible leaves or fruits or both, and those used in traditional medicine [2]. Among them is the African garden egg, *Solanum aethiopicum*, also called African eggplant. African eggplant arose from Africa and got dispersed throughout the Middle East and further to Asia [3]. It is widely cultivated in Nigeria and across the African continent [4]. It is called “ ìgbá or ikàn ” in Yoruba, “dauta” in Hausa and “afufa” or “anara” in Igbo languages of Nigeria. African garden egg forms part of the traditional sub-Saharan African culture. The fruits, said to represent blessings and fruitfulness, are offered as a token of goodwill and during visits, marriages and other social events. They are eaten raw and also, when boiled or fried, as ingredient of stews, soups and vegetable sauces. World production of eggplant in 2013 was estimated at 48.4 x 10^6 metric tons of fruit, ranking sixth after tomatoes, watermelons, onions, cabbages and cucumbers [5].

Wide variations exist within the vegetative and fruit characters both within and between the African eggplant species including variations in characters like diameter of corolla, petiole length, leaf blade width, plant branching, fruit shape, and fruit colour [6]. Their uses in indigenous medicine range from weight reduction to treatment of several ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease and swollen joint pains, gastro-esophageal reflux disease, constipation, dyspepsia [7; 8]. Several studies support the folkloric use of the plants in local foods and medicinal preparations. The significant analgesic, anti-inflammatory, anti-asthmatic, anti-glaucoma, hypoglycemic, hypolipidemic, and weight reduction effects of eggplants, particularly *S. melongena*, on test animals and humans have been reported [7; 9; 10; 11]. These pharmacological properties have been attributed to the presence of certain chemical substances in the plants, such as fiber, ascorbic acid, phenols, anthocyanin, glycoalkaloids and α-chaconine [12; 13]. Despite the fact that *Solanum aethiopicum* has been in use for a long time, particularly in Nigeria, for feeding and medicinal purposes, and despite the fact that there have been several reports on the assessment of the nutritive and pharmacological importance of the fruit, there has been a paucity of data on its fatty acids profile [14; 15; 16]. This study, therefore, has been carried out to evaluate the proximate composition and fatty acid profile of *Solanum aethiopicum* in order to elucidate its dietary importance and its usefulness to the daily needs of man.

Materials and method

Sample collection and preparation

Fresh fruit samples of garden egg - *Solanum aethiopicum* - were got from Obada market, Ipetumodu via Ile-Ife, Nigeria, identified by a plant Biologist in the Microbiology Department of the authors’ Institution above, and then kept in a refridgerator for further analysis.

Sample treatment

Proximate analysis

Moisture, ash, crude fat and crude fibre were determined in accordance with the official methods of the Association of Official Analytical Chemists [17]. Moisture content was determined by oven drying of 200g of each sample to a constant weight at 105°C. Crude protein content was determined by Kjeldahl method using 6.25 as the conversion constant after the determination of each sample’s nitrogen.

Crude fat content was determined by Soxhlet method using n-hexane as solvent. The ash content was determined gravimetrically after ignition at 550°C. Carbohydrate content was calculated by difference. All analyses were carried out in triplicates.

Fatty acid analysis

The fatty acids were converted to their methyl esters and the esters analysed using a PYE Unicam 304 gas chromatograph fitted with a flame ionization detector and PYE Unicam computing integrator. Helium was used as the carrier gas. The column initial temperature was 150°C rising at 5°C min-1 to a final temperature of 220°C. The injection port and detector temperatures were maintained at 220°C and 250°C respectively. The peaks were identified by comparing with peaks of standard fatty acid methyl esters under the same operating conditions.

Results and discussion

Proximate composition

The proximate composition of *Solanum aethiopicum* is as shown in Table 1. A high moisture content of 90.89% was observed for the fruit. This value is similar to 89.27 and 92.50% respectively, recorded for *S. aethiopicum* L and *S. macrocarpon* L varieties respectively and 89.0% for Gboma fruit (*S. macrocarpon*) by Leung, *et al*., but lower than 95.13% recorded for raw *S. incanum* and 94.8 and 94.6% for *S. gilo* and *S. aubergine* respectively [15, 16, 17, 18, 19]. Differences in percentage compositions of the same food type from different locations might be linked to factors like location, climate, variety or species, soil type, growing conditions, application of natural or artificial manure and the period of analysis [20]. The high moisture contents of the fruit is indicative of its freshness, making it to aid digestion better and thereby contributing to good and healthy living. But it also facilitates bacterial action on the fruit, giving it a very short shelf life and easy perishability [21]. 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 hydrolysis) a phosphate group from adenosine triphosphate (ATP) or guanosine

Table 1: Proximate composition of garden egg fruit

Parameter	% composition
Moisture	90.89
Dry matter	9.073
Crude fat	0.85
Crude protein	1.783
Crude fibre	2.29
Ash content	1.52
Carbohydrate	2.63

Triphosphate (GTP) to get energy [22]. It is also the containing medium for electrolytes and all other ions throughout the human body.

A protein content of 1.78% was observed for the fruit. This value compared well with the values of 1.6 and 1.40% obtained for *S. aethiopicum* and *S. macrocarpon* respectively, 2.24 and 1.33% reported for the same by Chinedu, *et al*. and 1.5% for *S. aethiopicum* by Grubben and Denton [4, 14, 18]. It is however lower than 8.90% for raw *S. incanum* recorded by Auta, *et al*., and 14.87 and 15.75% for *S. gilo* and *S. aubergine* respectively reported by Edem, *et al*. [15, 16]. Protein is important as a source of amino acids. It plays a part in the organoleptic properties of food, and it is also required for the formation of enzymes and hormones. In addition, it aids in the formation of antibodies that enable the body to fight infection [23, 24]. It is an essential food component needed in our bodies to repair, regulate and protect itself. On the other hand, protein deficiency causes growth retardation, muscle wasting, oedema, abnormal swelling of the belly etc [25]. The appreciable amount of protein in the fruit sample shows that it can be used as a protein source for man.

The ash content of the fruit was 1.52%. This is higher than 0.87 and 0.47% respectively for *S. aethiopicum L* and *S. macrocarpon L*., but lower than 4.06 and 5.58% of total solids respectively reported for round green *S. aethiopicum* and sweet white *S. macrocarpon* varieties and 23.78% for raw *S. incanum* [14, 16, 18]. The low ash content is reflective of the low level of mineral contents in the fruit sample. The fat content of 0.85% observed in the fruit is close to 1.0% reported for gboma, but higher than 0.1% reported for *S aethiopicum* and those of 0.52 and 0.17% respectively, found in *S. aethiopicum* and *S. macrocarpon* [4, 14, 19]. The low fat content does not favour its use as a source of oil commercially.

The fruit had a crude fibre content of 2.29%. This is slightly lower than 2.96% obtained for *S. aethiopicum* but higher than 1.11% for *S. macrocarpon* [14]. The high fibre and low carbohydrate contents in garden egg promote its consumption for weight loss. It fills up the tummy quickly and subsequently reduces the consumption of other high calorie options. The fibre content also helps to lower cholesterol levels in the human body, protecting the heart in the process. Dietary fibre helps to lower the risk of coronary heart diseases, hypertension, diabetes, colon and breast cancer, piles and appendicitis [26]. It is useful for maintaining bulk motility and increasing intestinal peristalsis by surface extension of the food in the intestinal tract. It is also necessary for a healthy condition, curing of nutritional disorders and for food digestion [27].

The garden egg fruit carbohydrate content of 2.63% obtained in this study is lower than 4.14 and 4.42% respectively obtained for *S. aethiopicum* and *S. macrocarpon* by Chinedu, *et al*., and 4.0% for *S. aethiopicum* reported by Norman [14, 28]. The fruit's low carbohydrate content means that it may not be a good source of energy in feed formulations.

Fatty acid composition

The fatty acid composition of the fruit oil of garden egg (*S. aethiopicum*) is presented in Table 2. The most abundant fatty acids were linoleic (32.65%), palmitic (20.71%), oleic (10.77%), stearic (9.02%) and lauric (7.22%) acids. Others of lower but significant concentrations were myristic acid (4.72%), arachidonic acid (4.64%), linolenic acid (3.17%), erusic acid (2.904%), palmitoleic acid (2.36%) and margaric acid (1.198%). Other fatty acids detected were in traces (< 1.00%), including caproic, caprylic, capric, behenic and lignoceric acids.

The linoleic acid content of this fruit, (32.648%), is slightly higher than 29.6% recorded for *Andrographis paniculata* seed oil and 30.0% for *Treculia africana*, but much lower than 68.3% recorded for *S. melongena* from the USA and 67.8% for *S. nigrum* from Congo Brazzaville [29; 30; 31; 32].

Linoleic acid, the most abundant fatty acid in the fruit, is of great importance as it prevents cardiovascular disorders such as coronary heart diseases and atherosclerosis, and also guides against high blood pressure [29]. Linoleic acid derivatives serve as structural components of the plasma membrane and as a precursor of some metabolic regulatory compounds. It

Table 2: Fatty acid composition of garden egg fruit oil.

Fatty acid	% composition
Caproic-C6:0	0.037
Caprylic-C8:0	0.067
Capric-C10:0	0.12
Lauric-C12:0	7.223
Myristic-C14:0	4.723
Palmitic-C16:0	20.710
Palmitoleic-C16:1	2.358
Margaric-C17:0	1.198
Stearic-C18:0	9.019
Oleic-C18:1	10.772
Linoleic-C18:2	32.648
Linolenic-C18:3	3.573
Arachidonic-C20:4	4.641
Behenic-C22:0	0.329
Erucic-C22:1	2.504
Lignoceric-C24:0	0.0823
Total saturated	43.508
Total unsaturated	56.492
Total mono-unsaturated	16.034
Total poly-unsaturated	40.862
Essential fatty acids	35.821
Oleic/Linoleic ratio	0.330
Linoleic acid/α-linolenic acid (LA/ALA) ratio	9.137
Total unsaturated/Total saturated (P/S index)	1.298

Helps to relieve rough and flaky skin and maintain smooth and moist skin [33, 34].

The high level of linoleic acid and the remarkable level of linolenic acid in the sample are very significant as both, which are the two essential fatty acids, apart from playing a natural preventive role in cardiovascular diseases, also promote the reduction of both total and high density lipoprotein cholesterol. Inappropriate balance of these fatty acids contributes to various kinds of malfunctioning while a proper balance maintains and even improves health. [20, 35].

The deficiency of σ-linolenic acid in man alters the course of brain development and perturbs the composition and physicochemical properties of brain cell membranes, neurones, oligodendrocytes, and astrocytes. These lead to physicochemical modifications, induce biochemical and physiological perturbations, and result in neurosensory and behavioural upset [36]. The presence of dietary omega-3 fatty acids in food enriches the food as they are involved in the prevention of some aspects of cardiovascular diseases (including at the level of cerebral vascularization), some neuropsychiatric disorders, particularly depression, as well as in dementia, notably Alzheimer's disease [29]. The importance of σ-linolenic acid also comes into play as it is used in the biosynthesis of arachidonic acid and thus some prostaglandins. Both arachidonic acid and the prostaglandins are required for cell growth and maintenance [37].

The nutritional importance of the fruit is further buttressed by the ratio of linoleic acid (LA)/σ-linolenic acid (ALA) of 9.137:1. This ratio fell within the ratio of between 5.1 and 10.1 recommended by the WHO/FAO [38]. The ratio of total unsaturated to total saturated fatty acids (P/S ratio) was 1.298. 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 [39]. The moderate ratio here obtained may not influence much the other properties of the seed oil.

The significant level of oleic acid (10.772%) in the fruit oil is also of great importance. Oleic acid plays a fundamental role in the prevention of cardiovascular diseases. It is also very important in nervous cell construction [40; 41]. The low oleic/linoleic ratio got for this oil sample reduces its use for deep frying because of its low stability for the purpose [42].

The high percentage of polyunsaturated fatty acids in the oil sample, especially linoleic and linolenic acids, gives it an advantage as these fatty acids are essential in the diets of man and needs to be supplied to the body for the proper functioning of the body system. The availability of arachidonic acid in this oil is also of dietary importance as it serves as a precursor of prostaglandin and thromboxane biosynthesis [12].

The presence and reasonable level of linolenic acid is also of nutritional importance as it is an essential polyunsaturated fatty acid used in the biosynthesis of arachidonic acid and thus some prostaglandins and also thromboxane [12, 37]. Both arachidonic acid and prostaglandins are required for cell growth and maintenance [37]. Erucic acid, present in the fruit oil, makes it important as the former serves as a precursor in bio-diesel fuel production [43].

The following saturated fatty acids were present in the fruit oil, making the fruit applicable for one or other important uses. Caprylic and capric acids make its oil useful in the production of esters used in perfumes. Caprylic acid is good in the treatment of some bacterial infections, because its chain length is short and has no difficulty in penetrating fatty cell wall membranes [44]. Capric acid is also used in the manufacture of lubricants, greases, rubber, dyes, plastics, food additives and pharmaceuticals [43]. Lauric acid is believed to have antimicrobial properties [45]. It can undergo β-oxidation to produce energy and can also be stored in adipose tissues [37]. Myristic acid is used as a raw material in cosmetics production. Palmitic acid is the first fatty acid produced during fatty acid synthesis and from which longer chain fatty acids can be synthesized [45;46]. 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). The low level of behenic acid in the seed oil (0.329%) is an advantage as a high level of it may make it difficult for the digestive enzymes in man and animals [47].

Conclusion

The proximate composition and fatty acid profile of *Solanum aethiopicum* from Nigeria was reported in this study. The fruit gave a higher percentage of unsaturated fatty acids compared to saturated fatty acids, and gave a good level of essential fatty acids, a value greater than 30% of the total fatty acid content of the fruit. These values make the fruit nutritionally rich and valuable. The low oil content, however, is a disadvantage for its commercial production.

Otherwise, the oil can serve as an alternative to other common vegetable oils for domestic and/or industrial purposes, thereby adding greater value to the seed, and hence, the fruit in the market.

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