Original Research Article

Physicochemical and Nutritional Composition of *Syzygium malaccense* Fruit from Nigeria

ABSTRACT

Background: There are many underutilized plants in many communities in Nigeria. Some have been reported to be nutritionally rich and contain variety of phytochemicals which need to be explored for human health and economic purposes.

Aim: To evaluate the physicochemical characteristics and nutritional composition of *S. malaccense* grown in Nigeria.

Methodology: Fruit weight, yield and pH were determined.Nutritional and chemical compositions of *S. malaccense* fruit parts were investigated using standard analytical methods. The samples were extracted with different solvents for percentage yield and phytochemical screening.

Results: The different part of the fruit exhibited significant differences ($p<0.05$) in their physicochemical characteristics. The flesh has a significant higher weight (104.6±19.57g) than the whole peel (25.85±4.838). The yield of the peel extract (11.315%) was higher than that of the flesh (6.231%) despite the higher weight of the flesh. The peel showed significantly ($P<0.05$) lower moisture content and higher levels of carbohydrates, proteins, fats, fibre, ash, dry matter and calorie when compared to the flesh. The flesh had the highest concentration of minerals with Calcium as the predominant macro-elements and Iron as the predominant trace minerals. The extract yield was dependent on the fruit part and solvent system with the peel as the fruit part and water as the choice solvent for higher yield. Phytochemicals like saponin, alkaloid, tannin, flavonoid, terpenoid, sterols, phenol and proanthocyanidin were also found present.

Conclusion: The nutritional and phytochemical components of *S. malaccense*, especially its peel may impart human and animal health when appropriately applied.

Keywords: [Myrtaceae, Syzygium malaccense, metabolite, nutrition, peel, flesh, phytochemical]

1. INTRODUCTION

Since time immemorial, human civilization has used several plants as food, medicine, clothing and shelter. It has been observed that numerous plants have pharmacological effects due to the presence of metabolites. Plant-metabolites are organic compounds which can be classified into primary metabolites and secondary metabolites. Primary metabolites are organic compounds include glucose, starch, polysaccharide, protein, lipids and nucleic acid which are beneficial for human growth and development. Plants synthesize secondary metabolites which include alkaloids, phenols, flavonoids, saponins, terpenoids, steroids, glycosides, tannins, volatile oils etc., The therapeutic efficacy of plants is because of these secondary metabolites for curing many diseases [1]. Epidemiological studies have consistently shown that regular consumption of fruits and vegetables is associated with reduced risk of developing cancer and other chronic diseases [2]. Fruits are considered rich sources of various primary and secondary metabolite which can provide several health benefits. Many of these edible fruits are abundantly available and underutilized. Therefore, they are usually not collected and wasted because their therapeutic properties and potential as subsidiary food sources are practically unknown to the communities [3].

One such underutilized fruit is *Syzygium malaccense* L. Merr & Perry which belongs to *Myrtaceae* family, with approximately 3,000 species of trees and shrubs[4].It is a species native of Malaysia, known as Malay apple that has adapted well in several countries with tropical and subtropical climates around the world[5]. The combination of tree, flowers and fruit has been praised as the most beautiful of the genus *Syzygium*[6]. It was introduced to Nigeria over 55 years ago where it is found in cultivation [7]. The main product of this tree is the fruit [8]. The fruit is pear-shaped and dark red in color depending on the stage of maturation or harvest conditions, although some varieties have white with streaks of red or pink, and white, crisp or spongy, juicy flesh of very mild, sweetish flavor.There may be a single oblate or nearly round seed or 2 hemispherical seeds, light-brown externally, green internally and somewhat meaty in texture. The fruits of some trees are entirely seedless [6]. The morphological and climatic adaptation of Malay apple in different geographical regions have been shown to reflect on its physical and chemical characteristics. In Brazil, research studies have shown that *S. malaccense* contains bioactive compounds with nutritional and pharmacological interest indicating that the pulp is a rich source of soluble fibers and reducing sugars and the peel concentrated with insoluble fibers, lipid content, vitamin C and a higher content of bioactive compounds, lipophilic/hydrophilic antioxidant power and anthocyanins [9,10]. A study by Lim and Rabeta [11] revealed appreciable amount of nutrients and high antioxidant activity of the fruit in Malaysia. In Nigeria, studies have shown that *S. malaccense* (L.) fruits contains appreciable mineral content, high amount of moisture, ash, fiber and vitamin C [12,13]. In Indonesian Borneo, the fruits are a source of income for local communities and the economic potential was found it to be profitable [14].

Considering the necessity of utilizing natural resources, there is need to investigate the nutritional composition of *S. malaccense* fruit with its part, particularly those in Africa with dearth of scientific data, hence, the thrust of this study. Therefore, this study evaluated the physiochemical and nutritional composition of *S. malaccense* cultivated under Nigeria climate conditions.

2. MATERIAL AND METHODS

2.1 Collection and Plant Identification

Fresh ripe *S. malaccense* fruits were harvested from Isefun in Lagos State, Nigeria ($6^0$34'33.8''N and $3^0$12'08.5E; $6^0$34'40.8''N and $3^0$12'01.3''E) in January, 2020. The plant materials were taxonomically identified and authenticated at the Department of Botany, University of Lagos, Lagos where a voucher specimen (LUH 7646) was deposited.

2.2 Physicochemical Characterization

20 fruits were weighed using a digital balance. The parts were manually separated using a stainless steel knife, yielding three fractions: peel, flesh and seed. Their weights were recorded. The percentage yield of the fractions were determined as the ratio of their respective weight and fruit weight, multiplied by 100. The pH of the peel (P; parts of the apple removed by the stainless steel knife), flesh (F; edible portion of the apple without the peel) and peel + flesh (PF; edible portion of the apple with the amount of flesh and peel maintained in the same proportions as in the whole apple fruit) were measured using a digital pH meter.

2.3 Nutritional Analysis

2.3.1 Proximate Composition Analysis

Proximate composition of fresh *S. malaccense* P, F, PF samples were reported in percentage and determined using standard analytical methods [15,16]. The percentage moisture content was determined by drying 5g of the samples at 105^0C until a consistent mass was recorded. The ash composition was determined by incinerating 5g of the samples at 550^oC for 6 h in a muffle furnace and the weight of the residue remaining after ashing was calculated as percentage ash content. The Soxhlet technique was used to extract crude fat from about 5g of each dried sample using petroleum ether. The Micro-Kjeldahl method (N x 6.25) was used to calculate the crude protein content of 5.0 g of the dried samples with a catalyst and the standard AOAC [15] method was used to assess crude fiber. The total carbohydrate content of the different samples was determined by the difference method according to the following formula:

Carbohydrate (%) = 100 – (% moisture + % ash + % crude fat + % crude protein + % crude fiber)…………………………………………………………………………….(Equation 1)

Dry matter or total solid of the different samples was calculated by subtracting the percentage of moisture from hundred [16]. The total energy value of the samples in kcal/100 g was obtained using the following formula [17]:

Calorific value = 4 x (% protein) + 9 x (% fat) + 4 x (% carbohydrate) ……. (Equation 2)

2.3.2 Mineral content analysis

Standard analytical methods according to AOAC [15] was also used for the determination of the level of mineral contents of *S. malaccense* P, F, PF by acid digestion using nitric acid and perchloric acid mixture (HNO_3: $HClO_4$, 5:1 v/v). The total amounts of minerals: Sodium, Magnesium, Calcium, Potassium, Iron, Copper, Manganese, Zinc and Lead in the digested samples were determined using atomic absorption spectrophotometer (AAS-Buck 205, USA). The values obtained were converted to mg/100 g of fresh sample.

2.3.3 Phytochemical screening

Extraction was done as described by He and Liu [18] with little modification. Fresh *S. malaccense* fruits were weighed and washed with water, separated manually into parts (peel, flesh and seed). The peel and flesh were dried separately to constant weight at room temperature and the seed was discarded. The dried peel and flesh were pulverized with the aid of Binatone electrical miller (BL-1500PRO). The ground samples were then stored in air tight bags at room temperature until use. 250g of the dried peel and flesh were soaked separately and homogenized with different solvents (water, 70% ethanol and 70% acetone; 1:2, w/v). The homogenates were filtered under vacuum with a Buchner funnel and Whatman No. 1 filter paper. The ethanol and acetone extracts were concentrated to dryness under reduced pressure using a rotary evaporator while the aqueous filtrate was concentrated using a freeze dryer. Qualitative analysis was carried out to ascertain the presence of different phytochemicals such as saponin, alkaloid, tannin, flavonoid, terpenoid, sterols, phenol and condensed tannins (proanthocyanidin) in *S. malaccense* extracts [19].

2.4 Statistical analysis

All of the analyses were carried out in triplicate and results expressed as mean ± S.D (Standard Deviation). The data were analyzed using GraphPad Prism 9 software, Incorporated, USA. One-way Analysis (ANOVA) was used to compare differences among the groups. The results were considered significant at the value of $p< 0.05$.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of *S. malaccense* Fruit

The result of the physico-chemical characteristics of *S. malaccense* is represented in Table 1. There are significant differences ($p<0.05$) in the physicochemical characteristics between the different part (peel, flesh and seed) of the fruit. The average weight of the fruit, peel, flesh and seed were 143.70g, 25.85g, 104.6g and 13.25g which is high when compared to 35.57g - 75.86, 9.97g - 11.52g, 38.80g - 40.93g, 12.09g - 11.11g obtained from different geographical locations in Brazil [9,10,20]. The percentage yield of the peel, flesh and seed were 17.989%, 72.792%, and 9.222%. The yield of the peel extract from its part is higher than that of the flesh despite the higher weight of the flesh. Also the ratio of the fresh peel (517.04g) to flesh (2092.23) is about 1:4 while the ratio of their extract yield from the fresh fruit weight reduced to 1:2 (2.035: 4.535) indicating that the peel presents a higher concentration of bioactive compounds. The pH value of *S. malaccense* peel is significantly lower than that of the flesh as observed by Nunes *et al.*[10] who reported 3.54-3.60 (P), 3.75-3.82 (F), although these values are lower than the those in this study. The difference in this result when compared to other study is expected because the physico-chemical characteristics in fruits are dependent on genetic and environmental factors [21] and production practices [22].

Table 1. Physicochemical characteristics of *S. malaccense* fruit

Parameters	Fruit (Peel+Flesh)	Peel	Flesh	Seed
Weight of 20 apples (g)	2894.24	517.04	2092.23	265.06
Mean weight of 20 apples (g)	143.7 ± 24.91^a	25.85 ± 4.838^b	104.6 ± 19.57^c	13.25 ± 3.991^b
Yield of fruit parts (%)		17.989	72.792	9.222
Weight of aqueous extract (g)		58.501	130.358	
Yield of extract from fresh part weight (%)		11.315	6.231	

Yield of extract from fresh fruit weight (%)		2.035	4.535
pH	3.945±0.0354[a,b]	3.800±0.0566[a]	4.000±0.000[b]

Values with superscript in a row are significantly (P<0.05) different.

3.2 Proximate composition of *S. malaccense*

The proximate composition expressed in % (g/100 g, wet basis) and total energetic value (Kcal/100 g, wet basis) of *S. malaccense* shown in Table 2 revealed lower values of moisture and higher contents of carbohydrates, proteins, fats, fibre, ash, dry matter and calorie in the peel when compared to the flesh. The moisture content is dependent on humidity, temperature and harvest time of the species. The moisture contents of the peel, flesh, peel+flesh were significantly different from one to another. The flesh has significantly ($p < 0.05$) higher moisture content than the peel and peel+flesh. The moisture content for the peel (84.56±0.6746) is lower than the reported value of approximately 90% by [10]. The moisture content for the peel +flesh (86.94±1.131) is lower than the reported value of 90 by [12] and higher than 83.28 ± 0.16 reported by [11]. The high moisture content in the flesh account for its reduced extract yield. The high moisture content is typical of fresh fruits at maturity and provides part of the medium for normal functioning of enzymes and general metabolic processes [23]. It is also responsible for the susceptibility of fruit to microbial attack during storage and this has been a serious challenge in food preservation [24]. The carbohydrate content of the flesh was significantly ($p < 0.05$) lower than the peel and peel+flesh. The carbohydrate content for the peel and flesh are lower than the reported value of approximately 7% (peel) and 5.05-6.48 (flesh) by [10]. The carbohydrate content for the PF (5.765±1.082) is lower than the reported value of 6.74-12.68 [11,12]. Fruits with very low carbohydrate content cannot supply enough energy as required by the body physiological needs, hence, are regarded as bad source of energy or low calorie fruits like Blueberries [25]. Therefore, *S. malaccense* (L.) fruits is a good source of pharmaceutical agents that may be suitable for the management of hyperglycemic related conditions like obesity and diabetes mellitus [12]. The peel has higher amount of Protein, fat, fibre, ash than the flesh. The Protein, fat, fibre, ash content in the fruit fractions are higher than other reported values [10,11,12]. The protein content in *S. malaccense* is low as seen in other fruitssuch as breadfruit, cactus pear, sweetsop and bacuri [26]. Fruit proteins, when present, are of low biological value and cannot be used to replace meals, or they must be consumed together with another source of food that provides such proteins in the quantities and qualities required [27]. The fat content in the fruit fractions are very low which is common for fruits like eggfruit, lychee, banana[26]. The fibre content is comparable with other dark-colored fruits, such as blueberries (2.40%), strawberries (2.00%) and can be considered fiber sources [10]. Fiber is an essential component of many diets as it increases food bolus and enhance digestion thereby reducing the risk of constipation. It may be used as an important agent for management of hypercholesterolemia and related nutritional disorder [12]. The ash content value compared favourably with most fruits' value such as like orange, watermelon, bush mango but higher than pawpaw, banana, apple, guava, soursop and pineapple [23]. The percentage ash of the sample gave an idea about the inorganic content of the samples from where the mineral content could be obtained. Samples with high percentages of ash contents are expected to have high concentrations of various mineral elements, which are expected to speed up metabolic processes and improve growth and development [28]. The observed wide range in dry matter and moisture in *S. malaccense* are similar to other fruits and this accounts for rapid deterioration of fruits if left unprocessed for long time after harvesting [23]. Carbohydrate, protein and lipid are the calorie contributors. The content of the calorie contributors in the peel is higher than the flesh, thereby corresponding to the high calorie value of the peel. Also, carbohydrate is the highest calorie contributor in this study as the total lipid and protein contents do not significantly affect the total energy value of the fruit, this is in agreement with other studies [10,11]. Therefore, *S. malaccense* can be included in calorie-restricted diets.

Table 2. Proximate composition of *S. malaccense* peel, flesh and peel+flesh

Parameters	Peel	Flesh	Peel+Flesh
Moisture	84.56±0.6746^{a}	89.97±1.075^{b}	86.94±1.131^{c}
CHO	6.425± 1.219^{a}	3.035±1.181^{b}	5.765±1.082^{a}
Protein	2.135±0.1909	1.410±0.014	1.605±0.07071
Fat	1.150±0.07071	0.8300±0.0424	0.925±0.09192
Fibre	3.330±0.000	2.455±0.2192	2.330±0.000
Ash	2.400±0.2828	2.300±0.1414	2.435±0.050
Dry matter (g)	15.44±0.6746^{a}	10.03±1.075^{b}	13.06±1.131^{b}
Calorific value (kcal)	44.59±3.476^{a}	25.25±4.398^{b}	37.81±5.183^{a}

Results are expressed as mean ± Standard deviation of three determinations. Values with superscript in a row are significantly (P<0.05) different

3.3 Mineral composition of *S. malaccense*

The mineral composition of *S. malaccense* is shown in Table 3. The result showed that the flesh contains the highest concentration of minerals than the peel in the fruit with Calcium as the predominant macro-element and Iron as the predominant trace minerals. Minerals are essential for the correct functioning of the human body; therefore, reference values for their intake are established and periodically reviewed in the light of new findings [29]. The recommended dietary allowances (RDAs) and adequate intakes (AIs) are parameters used to stipulate the nutrient levels that meet the human needs of healthy individuals. According to these parameters, the average daily requirements for adults (men and women, from 19 to 70 years) of the evaluated minerals per day are as follows: Ca, 1000 mg; Mg, 320 to 420 mg; Na, 1500 mg; K, 4700 mg; Fe, 8 to 18 mg; Zn, 8 to 11 mg; Cu, 0.9 mg/day and Mn,1.8 to 2.3 mg/day [30]. *S. malaccense* fruit was found to contain rich minerals like Calcium, Magnesium, Sodium, Potassium, Iron, Copper, Manganese and Zinc, with the highest quantity found in the flesh. This is in agreement with the result of Enidiok and Attah [13]. The mineral content in the *S. malaccense* decreased in the following order: Mg > K > Ca > Na > Fe > Cu > Zn >Mg (peel), Ca > K > Mg > Na > Fe > Cu > Zn > Mg >Pb (flesh and peel+flesh).Calcium is effective in the building of skeletal structures, muscle functioning, Magnesium is important in the ionic balance and enzyme co-factors [31]. Magnesium cooperates with calcium in the muscular contraction and blood coagulation [32].

Sodium and potassium which are present in the intracellular and extracellular fluid helps to maintain electrolyte balance and membrane fluidity [33]. However, accumulating evidence suggests that the average consumption of Na in the world is well above the necessary intake for the correct functioning of the body [34]. Evidence is building the important of considering sodium consumption in relation to potassium consumption for cardiovascular health outcomes. According to the World Health Organization, the ideal Na:K ratio is 1.0 and, overall, lower ratios are associated with better health outcomes [35,36]. Studies measuring the ratio of sodium to potassium (Na:K) have found that a lower ratio is associated with better blood pressure and cardiovascular health [37]. Na:K ratio in *S. malaccense* is less than the ideal ratio, which favors better blood pressure and cardiovascular health.

Trace amount of lead was detected in *S. malaccense* flesh only, which was lower than that reported in *S. cumini* flesh [38]. Lead is one of the most toxic metals among micronutrients. It is ingested by human beings by various means like contaminated food, use of lead contaminated plants and from environment. The ingestion of lead in high concentration causes its accumulation in body producing various toxic effects like renal, digestive and cardiovascular problems but it has no known biological function in the body [39]. The permissible limit of lead for herbal material according to WHO is 1mg/100g while the daily recommended consumption of lead for 70kg adult is 0.250 mg/day [40]. The concentration of lead in *S. malaccense* flesh is nontoxic in comparison with the recommended limit and it is of no insignificant as lead was not detected in PF. Based on the RDA (AI), *S. malaccense* can be considered a natural source of minerals with > 50% the minimum RDA of Cu and Fe and a range of 2-20% the minimum RDA of the other minerals.

Table 3. Mineral composition of *S. malaccense* peel, flesh and peel+flesh

Minerals (mg/100g)	Peel	Flesh	Peel+Flesh
Ca	44.91±16.63[a]	156.2±38.70[b]	106.9±17.47[c]
Mg	70.05±11.92	78.60±20.63	72.21±21.15
Na	29.41± 1.95	53.33±5.19	40.73±0.26
K	63.92±3.46[a]	137.5±1.78[b]	82.17±9.04[a]
Fe	0.9084±0.68	8.465±0.28	6.097±2.49
Cu	0.6776±0.15	1.178±0.51	1.003±0.52
Mn	0.08287±0.049	0.3161±0.036	0.1170±0.043
Zn	0.3874±0.031	0.6729±0.22	0.5091±0.12
Pb	-	0.1278±0.18	-
Na:K	0.460	0.388	0.496

Results are expressed as mean ± Standard deviation of three determinations. Values with superscript in a row are significantly (P<0.05) different

3.4 Percentage Yields and Phytochemical content of *S. malaccense*

S. malaccense extracts were obtained by using water, 70% aqueous ethanol and acetone. The resultant percentage yield after extraction was reported in Table 4. The yields of extraction of the peel and flesh of *S. malaccense* by various solvents decreased in the following order: AP> EP> AF> EF> ACP>ACF (Table 4) indicating that the extraction efficiency favors the highly polar solvents. Extraction is the first step of phytochemistry research, which is also necessary before isolation of effective constituents. The purpose of extraction is to get the objective chemical constituents to the utmost extent and avoid or reduce the solution of unwanted constituents [41]. The variation in the extraction yield depends on nature of the solvents and the chemical nature of the sample [42]. The result showed that extraction yield increased with increasing polarity of the solvent used and the peel had higher yield for all solvent indicating the presence of more bioactive compounds than the flesh.

Table 4. Percentage yield of different extracts of *S. malaccense*

Sample	Aqueous Peel	Aqueous Flesh	Ethanol Peel	Ethanol Flesh	Acetone Peel	Acetone Flesh
Weight of dried fruits (g)	250g	250g	250g	250g	250g	250g
Weight of dry extracts (g)	166.196	158.201	158.282	151.102	95.006	91.980
Percentage yield (%w/w)	66.478	63.281	63.313	60.441	38.002	36.792

The result of the phytochemical screening carried out on the solvent extracts of *S. malaccense* peel and flesh is shown in Table 5. The phytochemical studies revealed the presence of saponin, alkaloid, tannin, flavonoid, terpenoid, sterols, phenol, proanthocyanidin and reducing sugar. A remarkable presence of alkaloid, tannins, flavonoid, phenol and proanthocyanin in the peel when compared with the flesh in which the bioactive compounds were present in lower concentrations. A higher intensity of flavonoid and phenol were detected in the peel and reducing sugar in the flesh. Terpenoid was not detected in all the flesh extracts. Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. Medicinal value of plants lies in their phytochemical constituents which differ widely in terms of structure, biological properties and mechanisms of actions. These phytochemical constituents are known to be responsible for antioxidant, antimicrobial, anti-larvicidal, and anti-inflammatory activities [31,43]. Fruits are good sources of phenolics, flavonoids, and anthocyanins which are responsible for antioxidant, anti-carcinogenic and health-promoting properties [44]. The presence of these secondary metabolites in *S. malaccense* may contribute to its medicinal value. This result is in agreement with the findings of Batista*et al.* [9] and Nunes*et al.* [10] who reported a higher content of bioactive compounds and antioxidant activity in *S. malaccense* peel.

Table 5. Phytochemical Constituents of *S. malaccense* fruit extracts

Phytochemicals	Test	AP	AF	EP	EF	ACP	ACF
Saponin	Frothing	+	+	+	+	+	+
Alkaloid	Mayer’s	++	+	++	+	++	+
Tannin	Ferric chloride	++	+	++	+	++	+
Flavonoid	Alkaline reagent	+++	++	+++	++	+++	++
Terpenoid	Salkowski	+	-	+	-	+	-
Sterols	Liebermann-Burchard	+	+	+	+	+	+
Phenol	Ferric chloride	+++	++	+++	++	+++	++

Proanthocyanin	HCl, ammonium solution	++	+	++	+	++	+
Reducing sugar	Fehling's Test	++	+++	++	+++	++	+++

Keys: indicates the intensity of the phytochemical; - Absent, + Present in low concentration, ++ Present in moderate concentration, +++ Present in high concentration.

4. CONCLUSION

The edible parts of the *S. malaccense*fruit are rich in nutrients with a higher amount of moisture and minerals in the flesh and a higher amount of carbohydrate, protein, lipid, fibre, phenol and flavonoid in the peel. The extract yield was dependent on the fruit part and the solvent used. In terms of the fruit part, the peel had a higher yield indicating the presence of more bioactive compounds than the flesh. In terms of the solvent, water was the choice solvent with a higher yield. The result obtained in this study showed that *S. malaccense* contains appreciable amount of primary and secondary metabolites vital in promoting good health and disease prevention. Expanding its cultivation and utilization is highly recommended, thus improving the nutritional status of people, the economic value of the fruit and providing a source of income for local communities.

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