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# Physicochemical Studies on the Stem bark of the African Custard Apple (*Annona senegalensis Pers*)

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**Abstract**

Plants are important natural resources that are exploited for the general well-being of society because they are rich sources of food, medicines, energy, income, and shelter for millions of people around the globe. The study was conducted to provide information on the physicochemical composition of the main stem bark of A. senegalensis. The method used to determine the proximate composition of the plant's stem bark was the Association of Official Analytical Chemists (AOAC). The study revealed that the physicochemical composition of A. senegalensis stem bark contained crude fibre 44.02%, crude fat 4.10%, crude protein 4.29%, moisture content 39.19%, ash content 8.13%, and carbohydrate 39.19% respectively. A correlation coefficient was conducted to determine the significant of difference between the nutrients in the stem bark of A. senegalensis species. The means were separated using Pearson's correlation coefficient at $P \leq 0.05$ (2-tailed). The results showed a perfectly positive correlation ($r = 1.0$) at $P \leq 0.001$ between moisture content and carbohydrate. There was also a strongly negative correlation ($r = -0.9$) at $P \leq 0.001$ across crude fibre, moisture content, and carbohydrate. Finally, there was a moderately negative correlation ($r = -0.6$) at ($P \leq 0.05$) across ash content, moisture content, and carbohydrate. The results of this study could be the rationale for the considerable use of A. senegalensis stem bark and other parts of the plant as food for humans, animals and in herbal medicine across Sub-Saharan Africa.

**Keywords:** Proximate analysis; Annona senegalensis; Stem bark; Herbal medicine; carbohydrate

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## Introduction

Plants are useful natural resources that contribute immensely to the physiological and health needs of millions of people around the globe [1]. As pointed out by [2], plants are inevitable to both humans and animals because they depend directly or indirectly on them for survival. It is estimated that Africa is home to 25% of the world's remaining forest and millions of people across the continent exploit the floral diversity for their benefit [3, 4].

In Sub-Saharan Africa alone, more than 70% of the population depends on forests and woodlands for their livelihood. It is reported that more than one-fifth of families in rural communities in Sub-Saharan Africa obtain their daily needs from forests and woodlands and approximately 90% of the population living in these areas rely on wood resources for their household energy needs [4, 5]. In Ghana, trees play a pivotal role in household income generation and food security. Approximately 2.5 million of the population of Ghana rely on forest and woodland resources for sustainable income [6].

The genus (Annona) belongs to the family Annonaceae. Annonaceae is one of the largest plant families with an estimated 2400 species distributed in about 120 genera. About 40 genera and approximately 450 species of the plant are found in Africa and Madagascar [7]. A. senegalensis is native to the tropical east, northeast, west, and west - central including Southern and sub-tropical Africa. A. senegalensis is widely distributed across Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Uganda, the Democratic Republic of Congo, Ethiopia, Gambia, Guinea, Kenya, Lesotho, Mali, Mozambique, Botswana, Cameroon, Congo, Ghana and Cote d'Ivoire [8, 9]. In Ghana, A. senegalensis is widely distributed in the northern parts of the country, particularly the Northern, Upper West, Upper East, Savannah, and North East regions including the transitional zones where it is harvested as food and fodder [10].

Morphologically, A. senegalensis is a shrub that grows up to 7m in open grasslands but may reach 11m under favourable environmental conditions. The stem bark is smooth to rough and is grey-brown in clour. Leaves are alternate, simple, and oblong with bluish–green coloration [11] (**Figure 1a** and **b**). The flowers are up to 3cm long in

diameter with 2cm long stalks which may be solitary or in groups that emerge above the leaf axil. The fruits of the plant are formed from many fused carpels. Unripe fruits are green in colour and turn yellow to orange when ripe with numerous seeds that are oblong with orange to brown colour [9].

The economic importance of multipurpose tree species including A senegalensis has been well documented [8, 11, 12]. Economically, A. senegalensis is an important source of edible fruits. There are also reports that some oils extracted from the seeds of the plant may have been used for the production of edible oils and serve as important ingredients for soap production [7]. All parts of A. senegalensis have been reported useful for traditional herbal medicines. Leaves of the plant have been used in the treatment of smallpox disease, yellow fever, and tuberculosis [13]. The roots have been used in treating snake bites, swelling of body parts, and scorpion stings [14]. The stem bark of A. senegalensis has been used widely by traditional healers all over Africa for diarrhea, snake bites, toothache, and respiratory infections [11]. The presence of phytochemical compounds such as saponins, steroids, flavonoids, and glycosides has been documented [8]. Besides, the use of A. senegalensis for the control of insect pests has been documented in Nigeria and Tanzania [13].

Research on the proximate composition of various parts of A. senegalensis has been ongoing for some time now. [8] earlier reported that A. senegalensis seeds contain 12.2% moisture, 12.10% ash, 24.00% fat, 17.60% crude fibre, 8.80% crude protein, and 25.3% carbohydrates. [2] observed the presence of 92.3% dry matter, 7.79% moisture content, 33.0% crude fibre, 2.7% crude protein, 2.0% ash content, 2.0% ether extract, and 55.0% carbohydrate in the leaf of A. senegalensis. Similarly, [15] found that A senegalensis flower contains 76.96% carbohydrate, 8.37% crude protein, 7.67% moisture content, 7.33% ash, 4.17% lipid, and 3.17% fibre. [10] indicated that the leaves of A. Ssenegalensis serves as good fodder for livestock. Despite the extensive research on the proximate composition of A. senegalensis, leaves, flowers, fruits, and seeds [2, 15], presently there is still a paucity of information on the proximate composition of the main stem bark of the plant. This study therefore sought to provide the proximate information on the stem bark of A. senegalensis to complement what has been done so far on other parts of the plant.

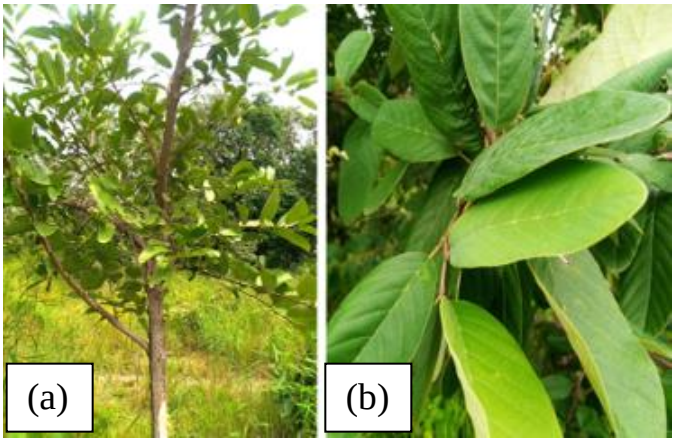


**Figure 1** (a) A. senegalensis plant. (b) A. senegalensis leaves

## Materials and Methods

### *The study area*

The study was conducted in West Gonja Municipality located in the Savannah region of Ghana with Damongo as its headquarters. The Municipality is one of the 7 administrative assemblies in the region. Geographically, the Municipality lies on longitude 10 5″ and 20 58″ West and latitude 80 32″ and 100 2″ North. The Municipality covers a total land area of 4,715 km2 and shares boundaries to the south with Central Gonja district, Bole, and Sawla- Tuna - Kalaba districts to the west and North Gonja district to the north [16].

The Municipality generally has an undulating topography with altitude between 150-200 meters above sea level. Soils around the Damongo enclave in particular are generally low in fertility. However, soils around neighbouring communities such as Mankarigu and Lingbinsi are generally said to be fertile for the cultivation of root crops, cereals, and legumes [17]. The mean monthly temperature is around 27ºC although temperatures in the area are generally high with the maximum occurring between March-April and the minimum occurring between December and January every year [16].

The area experiences a unimodal rainfall pattern which starts around March to April and ends around October each year. The average annual rainfall is approximately 1144mm. The dominant vegetation in the area is guinea savannah. The commonest economic trees in the area are Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata, Acacia spp, and Diospyros melipisiformis [18]. The dominant occupations in the area are agriculture, forestry, and

fishery (60.5%), craft and related activities (14%), and service and sales sectors (12. 2%) with only (8.5%) engaged as managers, professionals, and technicians [19].

***Collection and preparation of plant materials***

The main stem bark of A. senegalensis was harvested from six different trees in different locations on the outskirts of Damongo in the West Gonja Municipality of the Savannah region of Ghana. Fresh samples were harvested from mature trees at the midsection at different geographical coordinates as follows; Plant A: 9.120318N and -1.835533W, Plant B: 9.120306N and -1.835678W, Plant C: 9.125254N and -1.839123W, Plant D: 9.125688N and -1.838765W, Plant E: 9.105216N and -1.826975W and Plant F: 9.1015348N and -1.827160W. The distance between the six plants was approximately 2 kilometers apart. The plant materials were taxonomically authenticated in the Department of Biodiversity Conservation and Management at the University for Development Studies, Tamale.

The outer layers of the bark which mostly comprise dead cells were removed to facilitate the drying of the samples. The remaining samples were then cut into smaller pieces, thinly spread on a tray, and oven-dried at 600ºC continuously for four hours. The samples were then ground into fine flour for proximate analysis using an electric grinder. The study was conducted in the Savannah Agricultural Research Institute (SARI) Laboratory in Nyankpala, Tamale.

***Proximate composition determination of the plant stem bark samples***

The proximate compositions of the plant samples were determined using the Association of Official Analytical Chemists (AOAC) [20]. The following proximate compositions: Crude fibre, Crude fat, Crude protein, Moisture Content, Ash content, and carbohydrate were determined in the laboratory.

*Moisture Content Determination*

Empty tin cans were weighed and recorded. About 2 grams of the milled samples were then placed in the tin cans, weighed, and recorded. The samples were then placed in an oven at 150°C for 4 hours. After cooling for about 30 minutes, the samples were weighed again and recorded. Finally, the moisture content of the samples was calculated as follows:

Moisture content (%) = [(Initial weight - Dry weight) / Initial weight] x 100.

*Crude Fat Determination*

Approximately 2 grams of the ground bark samples were weighed and recorded. The samples were then placed in a thimble made of filter paper. The thimble was inserted into a fat extractor. An amount of 85ml of the samples was placed in a flask. The flask was gently heated causing the solvent to boil and vaporize for 30 minutes. As the vapour rises, it condenses in the condenser and drips the sample in the thimble for 20 minutes. The solvent gradually dissolves the fat from the sample as it cycles through the process. The extraction process continued for 15 minutes to allow the solvent to circulate through the sample. After extraction, the thimble containing the fat residue was removed from the fat extractor. Crude fat was then determined by the Soxhlet extraction method using ether as the extraction solvent.

Crude fat (% of DM) = weight of fat/weight of sample X 100%

*Crude Ash Content Determination*

The samples were ground or homogenized and a 2g portion of the prepared samples were put into a pre-weighed crucible that could withstand heat. The crucible was placed in a muffle furnace or furnace at a high temperature (typically 550-600°C) until all organic matter was completely burned off. This process determines the total inorganic ash content. After ashing, the crucible was left to cool in a desiccator. Finally, the weight of the sample was measured with the weight of the remaining ash.

Ash content (%) = Weight of ash/weight of sample X 100%

*Crude Protein Determination*

The crude protein of the samples was determined by the micro-Kjeldahl method. The sample was weighed into the digestion tube using filter paper. 15ml of concentrated sulphuric acid was added to each tube along with copper

sulphate as a catalyst and mounted on the digestion block. The digestion process runs for 4 hours. 50ml of distilled water was added to the tubes containing the digested samples along with 50ml of sodium hydroxide and then placed into a distillation machine. This process converts nitrogen in the sample into ammonium sulphate. About 20ml of Boric acid was put into a conical flask and then placed into the distillation unit for 5 – 10 minutes for each sample. After the colour turned green, the content was then distilled off the flask, and ammonia was liberated. The ammonia solution was titrated with a standardized solution of sulphuric acid (H2SO4). The amount of acid required to neutralize the ammonia is directly proportional to the nitrogen content in the sample.

Crude Protein (CP)% = Total Nitrogen (NT) x 6.25(Protein factor)

*Carbohydrate Determination*

The carbohydrate content of the samples was determined by taking the difference of the sum of all the proximate compositions from 100%. That is; Moisture Content + crude protein + crude fat + crude fiber+ ash content. Carbohydrate content (%) = 100% – (Fibre% +Fat% + moisture% + ash% + protein%).

***Data analysis***

Data obtained from the laboratory were analyzed using the IBM SPSS Software 2021 version. The results were summarised for their central tendencies and were presented as means and standard deviation (M ± SD). A correlation coefficient was conducted to determine the significant difference between the mean nutrients in the stem bark of A. senegalensis plant species. A Pearson Correlation Coefficient (r) was computed to assess the linear relationships among the plant nutrients (variables) and a significant difference was declared at $P \leq 0.05$ or $P \leq 0.001$ (2-tailed).

## Results and Discussions

The results of the chemical compositions of the main stem bark of A. senegalensis are presented in (**Table 1**). A. senegalensis stem bark samples were found to contain crude fibre (44.02%), crude fat (4.10%), crude protein (4.29%), moisture (39.19%), ash (8.13%), and carbohydrates (39.19%).

A correlation coefficient was conducted to determine the significant difference between the nutrients in the stem bark of the six A. senegalensis plant species and their mean values were separated using Pearson's correlation coefficient at $P \leq 0.05$ (2-tailed). The results indicated that there were perfectly positive (r = 1.0), strongly negative (r = -0.9), and moderately negative (r = -0.6) linear relationships between some of the variables (Table 1).

**Table 1** Pearson Correlation showing the proximate composition of *A. senegalensis* stem bark

| Components | M | SD | Carbohydrate | Ash content | Moisture content | Crude Protein | Crude fat | Crude fibre |
|---|---|---|---|---|---|---|---|---|
| Crude fibre | 44.02 | 12.01 | -0.971** | 0.549 | -0.971** | -0.170 | -0.355 | — |
| Crude fat | 4.10 | 2.35 | 0.212 | 0.092 | 0.212 | -0.083 | — | |
| Crude Protein | 4.29 | 0.86 | 0.122 | 0.623 | 0.122 | — | | |
| Moisture content | 39.19 | 11.91 | 1.000** | -0.663* | — | | | |
| Ash content | 8.13 | 1.41 | -0.663* | — | | | | |
| Carbohydrate | 39.19 | 11.92 | — | | | | | |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed). M=Mean, SD=Standard deviation.

According to [21, 22], crude fibre determination aims to identify indigestible ingredients such as cellulose, hemicellulose, and lignin in food samples that are not easily digestible by digestive enzymes in the digestive tracts of animals although these ingredients are very important for lowering blood pressure, blood glucose, and cholesterol levels. In this study, the crude fibre content of 44.02% of A. senegalensis stem bark was slightly higher than the values recorded for Pentadiplandora brazzeana stem bark at 41.03% as reported by [23]. It was also higher than the value recorded for A. senegalensis leaves at 33.0% as reported [2]. However, [24] reported a higher crude fibre value in the bark extract at 54.50% of Byttneria catalpifolia higher than what has been reported for A senegalensis in this study.

Crude fat forms part of the basic structural composition of cells that provides energy for essential fatty acids to speed up the absorption of fat-soluble vitamins [25]. The crude fat value of the stem bark of A. senegalensis at 4.10% was higher than the values recorded for the stem bark of Pterocarpus erinaceus at 0.45% as reported by [26].

Similarly, [27, 28] reported higher crude fat values for the stem bark at 9.13% of Cassia nigricans, and for the stem bark at 20.0% and leaves at 11.1% of Tectona grandis.

Crude protein determination is one of the most common measurements in the food and animal husbandry industries because it is required for body maintenance, healthy growth, lactation, and reproduction [29]. [30] reported a lower crude protein value of 1.49% for the stem bark of Cissus populnea. On the contrary, in the present study, we found a higher crude protein value of 4.29% in the stem bark of A. senegalensis. In like manner, [31] reported high crude protein values of 13.9% and 5.61% respectively in the leaves and stem bark of Alchornea cordifolia.

As specified by [23] moisture content of a sample provides detailed information on the amount of water in the sample and can used as an index to the storage life of the sample. The moisture content obtained in the stem bark of 39.19% of A. senegalensis was higher than those reported for Alchonea cordifolia leaves at 8.73% and stem bark at 10.07% respectively as reported by [31]. Similarly, [12] reported lower values of moisture content in the leaves at 2.96%, stem bark at 4.21%, roots at 4.36%, and fruits at 4.56% of Balanite aegyptiaca. Conversely, [32] reported higher moisture content values of 57.01% in the leaf extracts of Carica papaya.

Determination of ash content is an important initial step in proximate analysis that is required for nutrient evaluation to ensure that food is free of toxic minerals [33]. The ash content of 8.13% obtained in the stem bark of A.senegalensis was lower than the values reported for Vernonia amygdalina stem bark extract at 17.99% and root bark extract at 11.01% as reported by [34]. Likewise, [35] recorded a slightly higher ash content value for the seed at 8.36% of Ficus thonningii. Nonetheless, [36, 37] recorded lower ash content values for the stem bark at 8.11% of Piliostigma thonningii and for the leaf at 6.74% and stem bark at 7.46% of Pterocarpus osun respectively.

According to [38], carbohydrates play an important role in the body by acting as sources of energy, controlling glucose and insulin levels, and participating in cholesterol metabolism. The carbohydrate composition of A. senegalensis stem bark at 39.19% was lower than the mean values obtained for Morinda lucida leaves at 68.76%, stem bark at 80.9%, and roots at 81.63% respectively as reported by [39]. Comparably, [40] reported higher carbohydrate values for the stem bark at 88.76%, root bark at 91.83%, and leaves at 87.76% respectively of Uvaria chamae. [41] reported carbohydrate values higher than A senegalensis stem bark at 39.19%, 50.73%, roots at 40.25%, and stem bark at 40.30% respectively for Bobgunnia fistuloides. In contrast, the carbohydrate value of A senegalensis stem bark reported in this study was higher than the values obtained for Pentadiplandra brazzeana stem bark at 17.82%, Annona senegalensis seeds at 25.3%, Acacia catechu bark at 22.8%, root at 18.6% and leaf at 35.87% respectively as reported by [23, 42, 43].

## Conclusion and Recommendations

The proximate composition of the main stem bark of Annona senegalensis revealed that major nutritional contents are present in the plant. The nutritional values obtained varied considerably across the various nutrients determined in the stem bark. The study revealed that the stem bark of the plant is richer in crude fibre at 44.02%, carbohydrate at 39.19%, and moisture at 39.19% respectively, but lower in crude fat at 4.10%, crude protein at 4.29%, and ash respectively at 8.13%. The presence of these nutrients in optimum quantities gives the plant a potential for food and perhaps for medicinal purposes. We therefore recommend that further research should be conducted to determine the bioactive compounds such as terpenoids, polyphenols, and alkaloids present in the stem bark of A. senegalensis to further elucidate its health potentials.

### *Data availability*

The data used in this study have already been included in this manuscript.

### *Competing interest*

The authors of this manuscript have declared no competing interest.

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