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Morphological, and some physiochemical properties of subtropical senna plant (Cassia *angustifolia* & Cassia *obtusifolia*) from Sudan

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Abstract
The results of morphological, and some physiochemical analysis of two types of the subtropical medicinal plant Senna (Cassia *angustifolia* & Cassia *obtusifolia*) from Omdurman City, Sudan, revealed that the two species are small green shrub about 2 feet high on average. The C *obtusifolia* pods were curved (Sicklepod) rather than flat, and their seeds seem as sharp projection in the epidermis of the pods, some C *obtusifolia* pods contain more than 7 seeds, their leaves seem with a sharp top, compared with the rounded top of the C *angustifolia* leaves. The proximate composition of a mixture of C *angustifolia*, and C *obtusifolia* leaves, resulted in 18.88±0.20% crude protein; and 38.40±1.22% carbohydrate. Of minerals detected, the calcium level found as 919.55%. Results had approved the wide range and the high diversity of the different Cassia types in the subtropical region including Sudan and Nigeria.

Keywords: morphological; physiochemical; subtropical; senna; cassia

1. Introduction

Senna plant (*cassia angustifolia*) and *Cassia senna* L. (*Cassia acutifolia* Del.) (or a mixture of the two species), now collectively subsumed under the item Senna alexandrina Mill [1,2], it belongs to family Leguminosae [3]. These two species are very closely related [1, 2]. Besides, there are many other known types of Senna plant such as Northern Wild Senna (Senna hebecarpa), Senna *alata* Linn known in Nigeria as gungoroko, distributed from tropical America to India [4, 5], Senna *hirsute* L., and Senna *obtusifolia* L., which are the woody annual herbs or undershrub herbs are native to Africa as medicinal species with active therapeutic functions [6].

The *Cassia acutifolia* Delile (Alexandrian senna*),* and *C. angustifolia* Vabl. (Tinnevelly senna or Arabian senna) are the most widely used Senna species for medicinal purposes [7], they have desert origins [8]. Alexandrian Senna is obtained mainly from Egypt and Sudan [9], it is also called Khartoum Senna, and is traded under the name of Sana Makkah at herbal shops in Sudan. Today, Senna leaf and fruit are official in national pharmacopeias worldwide, to that, the World Health Organization (WHO) approves Senna leaf for short-term use in occasional constipation [10]. Alexandrian Senna pods (Sennae fructus acutifoliae) consist of the dried fruit of Cassia Senna L. (Cassia *acutifolia* Delile) [11]. But sometimes, the herbal substance of Senna consists of the dried leaflets of Cassia Senna L. (Cassia *acutifolia* Del.).

Senna is a native perennial wildflower, well known in Asian countries and subtropical areas, it is commercially cultivated in some countries including Sudan [12], that country is endowed with a range of edapho-climatic conditions that enhance the establishment of many plant species, such as Senna [13].

Senna trees, as many indigenous and seasonal fruit trees, may be an important genetic resource in global efforts to maintain biodiversity [14]. The indigenous trees may withstand harsh conditions such as drought, and heat stress [15], but the Senna grows only at the post-rain season. Although the species is self-compatible and therefore capable of inbreeding, it requires a pollinator to effect pollination [16].

Senna has been used for medicinal purposes for centuries. It was introduced into European medicine by the Arabs in the 9th or 10th century [17], mainly Senna leaves used as a laxative and purgative in cases of acute and chronic constipation [18-23]. The Pharmacopoeia Austriaca [24] lists Senna leaves as "infusum laxativum". Besides this laxative property, the Senna plant was used for treatment of malaria when decocted [25-27], influenza, digestive complaints, treat wounds, burns, and as secretolytic ointment in South Africa and Central Africa [28]. It is used also for bowel cleansing before diagnostic investigations or surgery [12], and used for many other alignments [19, 29-31].

Generally, the leaf, flower, root, and seed are used in herbal medicine all over the world [32], while there is no information from available literature, on the phytochemical screening and nutritive values of petals of S. *alata*, S. *hirsute*, and S. *obtusifolia* [33]. The minerals present in leaves show that the leaves are good sources of essential nutrients but the presence of the toxicants shows that these leaves should be properly processed before consuming them [30]. The extract is produced from the herbal substance by a suitable procedure using ethanol (50-80 percent V/V) [11].

Hydro xyanthracene derivatives are accepted as the active therapeutic constituents of this plant, the dried herbal substance contains not less than 3.4% of hydro xyanthracene glycosides [11]. This material is generally higher in the leaves than in the fruits [34], its benefit/risk ratio is considered positive as described in the European Union monograph [35].

Little information is available on the antimicrobial activity of the Senna plant, some studies showed antibacterial activity of the plant extract but not showed antifungal activity against fungi [36]. Particularly the plant leaves, not

the pods or seeds, solvent extracts exhibited these antibacterial activities [37].

The fruits of Senna are not usually directly edible by humans, but they dried and used only for the treatment of some diseases [38]. But some nations in Nigeria cook, boil, and eat young leaves of Senna *occidentalis* (Septic Weed or Coffee Senna) as a vegetable [39]. The pulp of the fruit is dried and milled to produce a fine flour [40], they may be packed and used as teabags for medical use. Usually the fruits and leaves of Senna are eagerly eaten by goats and birds on streets.

Some studies indicated that the leaves of both S. *obtusifolia* and S. *alata* can cause marked toxic effects on rats [42], and some Senna plants are suspected of causing serious effects in grazing animals [42]. In spite of the absence of reports about the toxicity of Senna in Sudanese livestock [42], some studies indicate that leaves of Senna are toxic to goats and death ensues, it seems likely that diarrhea may have resulted from an enterotoxic effect of the plant constituents [42].

Our study described some morphological, and some physiochemical properties of the subtropical medicinal plant Senna (cassia *angustifolia* & cassia *obtusifolia*), particularly from Sudan.

2. Materials and Methods

Senna *angustifolia*, and Senna *obtusifolia* entire bushes (small trees), with their branches, pods, and leaves were collected from Omdurman City, Khartoum State, Sudan. The plant materials were taxonomically identified and authenticated at the College of Agriculture of Khartoum University, Sudan. The Morphological investigation was based on macroscopic features of the plant. Many photographs had been taken and classified to report our morphological results.

The leaves of Senna plant were sun-dried and grounded using a food blender (without metal contamination), then a mixture of 250 grams form each Senna type were sieved and subjected to the following analysis. The phytochemical analysis had been done in triplicate, then means and standard deviations were recorded using Excel of Microsoft.

For extraction, the powdered leaves were accurately weighed and then cold in 400ml of 50% ethanol and distilled water for 72 hours at room temperature according to the method suggested by Sofowora (1993) [43]. The liquid extracts were filtered using cotton wool and glass funnel. The filtrate obtained was concentrated under vacuum at 40oC to yield a semi-solid mass. The extract obtained was accurately weighed and then used for phytochemical screening.

Determination of Moisture content (Ovum Method) was done according to the equation:

$$\% \text{ moisture} = \frac{\text{(Difference in weight X 100)}}{\text{Weight of sample used}}$$

For the determination of ash content and crude fiber, methods recommended by AOAC (1995) [44] were used. Soxhlet method of AOAC (1995) was used for the determination of fat content. The same reference had been used for carbohydrate determination, were the summation of [% fats + % Ash + moisture + % protein + % crude fiber] had been subtracted from the total number 100 (AOAC, 1995). Crude protein was determined by the methods described by AOAC (1990) [45].

To determine mineral constituents, Fe and Mg levels, one gram of the samples was digested using 15 mL of HCl and 5 mL of nitric acid (3:1), then the digested samples were tested using atomic absorption spectrophotometer (AAS. 6800) made by Shimadzu. The amount of calcium was determined by the method of (AOAC, 1997) [46], following the procedure: Exactly 10ml of the sample filtrate was pipetted into conical flask and 25ml of 10% potassium hydroxide was added into the same flask and a pinch of calcein indicator was also added. 0.1N EDTA was used to titrate the solution till colour changed from pinkish-green to full pinkish colour.

3. Results and Discussion

3.1. Morphological

We found two types of the Senna plant trees grow naturally on roads of the city, both of them are small green shrub about 2 feet high on average, and almost similar in their general morphology, but can be distinguished by some differences in the shape of leaves and fruits (pods). The most abundant type is similar to the species *Cassia angustifolia*, while the other type is similar to *Cassia obtusifolia*, according to description reported by some literature. The two tree types are almost growing near each other, making it difficult to distinguish them. The C *angustifolia* trees were highly branched, the branch contains many leaves and many pods growing near each other {fig 1}.

The pods of C *angustifolia* were broadly oblong; about 4 Cm long by 1.5 Cm broad, and contain six to seven seeds, this fact is previously recorded by the study of Dziedzic and Hudson (1984) [47]. The fresh pods were green, being turned to dark brown when being dry {fig 2}, these green pods had a smooth surface but may become slightly fissured when dry. The WHO reported a length of 20-40 mm; width of 5-15 mm for flat Alexandrian Senna leaf; and a length of 25-50 mm; width at the centre, 7-20 mm; for the lamina [48].

The C *obtusifolia* pods were curved (Sicklepod), and their seeds seem as sharp projections in the pod surface beneath the epidermis {fig 3}, some of these pods contain more than 7 seeds. The Yellow flowers of Senna plant were almost on the top of branches. {fig 4}.

Leaves of C *obtusifolia* seem with a sharp top, compared with the rounded top of the C *angustifolia* leaves {fig 5}.

Our findings were near what reported by Srivastava *et al*. (2006) [49] who distinguished C *angustifolia* by the presence of a greenish-brown or dark brown pod of 3 – 9 Cm in size, while C *obtusifolia* have a greenish pod, which is 10 - 15 Cm long.

Pods of some other Senna types from Africa such as Cassia *occidentalis* are longer and thinner than pods of Cassia *angustifolia*, and Cassia *obtusifolia*, as shown by the study of Aja *et al*. (2017) [39] {fig 6}. Some other Senna trees types reported in the literature were taller, Cassia *siamea* medium size tree up to 15-20 Cm tall, with a straight trunk up to 30 Cm in diameter [30, 50].

3.2. Physiochemical

A mixture of powdered naturally dry Senna (Cassia *angustifolia*, and Cassia *obtusifolia*) leaves (a mixture of 250 grams of each type) was tested for proximal parameters and some chemical constituents. The plant samples had been collected by hand from roads of the city, then were differentiated according to the morphological features of the

plant leaves and pods. Table (1) shows the Proximate composition of the mixture of C *angustifolia*, and C *obtusifolia* leaves, while Table (2) shows levels of the chemical elements of the mixture of C *angustifolia*, and C *obtusifolia* leaves. Our results had ensured the high diversity and variability
of constituents levels of the different types of Cassia (Senna) species. The Proximate analysis of the mixture of C *angustifolia* and C *obtusifolia* leaves revealed protein content almost similar to the C *alata* found by Abdulwaliyu (2013) [51], and C *siamea* found by Kendeson (2018) [52], but it seems far higher than what reported by Alli Smith (2009) [30] for C *siamea*, and by Aja (2017) [39] for C *occidentalis*, who reported protein as 4.01%, and 2.75±0.5%, respectively.

Fig 1: Tree of C *angustifolia*, branches, leaves, and pods.

Fig 2: Fresh green pod, and dry brown pod of Senna C *angustifolia*.

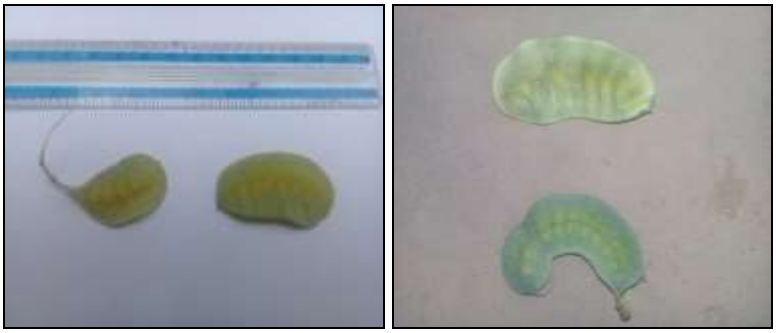

Fig 3: Flat Senna pod, and curved Senna pod (Sicklepod).

Fig 4: Yellow Senna flowers on the top of branches

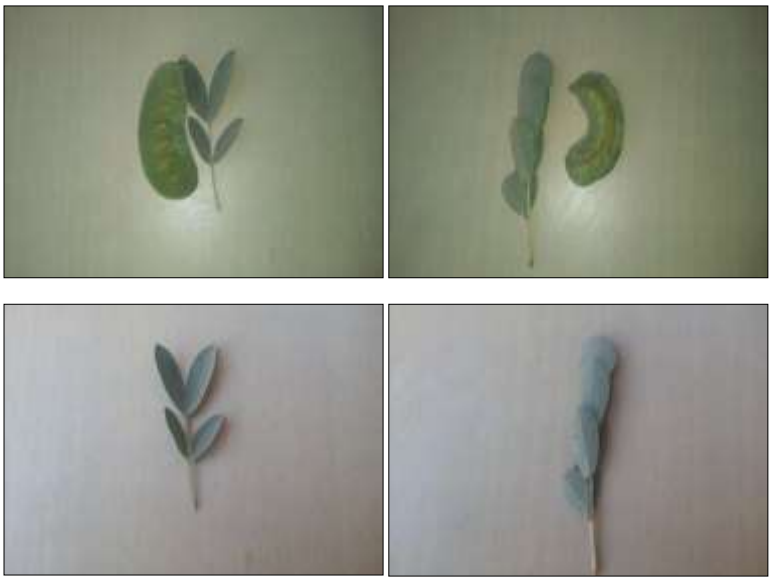

Fig 5: Leaves of C *obtusifolia* (sharp top) (A); Leaves of C *angustifolia* (rounded top) (B).

Fig 6: Senna C *occidentalis* growing in the wild. (Source: Aja *et al*. 2017) [39]

Table 1: Proximate composition of mixture of Cassia *angustifolia*, and Cassia *obtusifolia* leaves.

Parameter	Value %
crude protein	18.88 ± 0.20
crude fibre	10.10 ± 0.75
moisture content	03.00 ± 0.10
ash content	12.00 ± 0.03
carbohydrate	38.40 ± 1.22
crude fat	3.5 ± 0.25

Note: Values were expressed as mean ± standard deviation of three determinations.

Table 2: Chemical elements of mixture of Cassia *angustifolia*, and Cassia *obtusifolia* leaves.

Elements Determined	Value %
Ca	919.55
Fe	1.89
Mg	82.33

The crude fiber was found near those levels reported by many previous studies with few exceptions such as the low fiber levels reported for C *occidentalis*, and C *Singueana*, which were 6.89±0.6%, and 1.36, resp.

The ash content we found in our samples was in accordance with many studies done before, the exception of the low ash contents of C *occidentalis* (3.77±0.7%), and C *Singueana* (6.93%) cannot be considered as a distinguishing factor, that is, ash content detection may depends on the technique used rather than on the type of plant.

The carbohydrate level we found in our mixture was almost near those levels reported for C *siamea* (34.07%), but lower than that of C *occidentalis*, C *alata*, and C *Singueana*. The crude fat content we found was almost in accordance with many other Cassia species, with little exceptions. It seems that most of Cassia species contain similar carbohydrates and fat quantities, in spite of the high range of differences in the other biochemical features between Cassia types. Differences between the proximate compositions of some Cassia types were presented in Table (3).

Table 3: Comparison between the Proximate composition of Senna leaves (Cassia leaves) from different origins

parameter	Cassia siamea [52]	Cassia siamea [30]	Cassia Occidentalis [39]	Cassia alata Linn. [51]	Cassia alata (L) Roxb. [54]	Cassia obtusifolia [53]	Cassia Singueana [55].
Crude protein	21.88 %	4.01%	2.75±0.5%	18.23±0.13%	17.50 ± 0.57 %	21.87 ± 0.20%	11.38%
crude fibre	13.00 %	12.36 %	6.89±0.6%	15.73±0.03%	16.91 ± 0.51 %	18.72 ± 0.75%	1.36%
moisture	7.43 %	46.01 %	21.96±0.3%	4.49±0.50%	15.40 ± 0.17 %	NA	2.92%
ash content	20.62 %	17.93 %	3.77±0.7%	9.53±0.06%	6.00 ± 0.13 %	12.53 ± 0.03%	6.93%
carbohydrate	34.07 %	7.67 %	63.03±0.4%	47.73±0.01%	32.00 ± 0.61 %	36.41± 1.02%	74.09%
crude fat	3.00 %	12.02 %	1.62±1.0%	3.91±0.01%	9.80 ± 0.21 %	3.97 ± 0.24%	3.32%

NA: Not Available

Our finding of the Ca level was near those levels found by Nuha (2010) [53] study on C obtusifolia from two Sudanese regions, which are 967.65 and 751.28, resp., but it was much higher than levels reported for C *occidentalis*. The Fe level was low

Compared to what reported by most previous studies on different Senna (Cassia) types. Differences between calcium, Iron, and Magnesium levels of some Cassia types from the subtropical region, reported in the literature, were presented in Table (4).

Table 4: Comparison between the chemical elements levels of Senna leaves (Cassia leaves) from different origins

Elements	Cassia siamea[52]	Cassia siamea [30]	Cassia Occidentalis [39]	Cassia alata Linn. [51]	Cassia obtusifolia [53]	Cassia obtusifolia[53]	Cassia Singueana[55]
Ca	3.08 %	ND	0.77±0.01 mg/100g	158.38%	967.65%	751.28%	600%
Fe	11.03 %	112.00 ppm	2.46±0.01 mg/100g	42.35%	2.68%	2.60%	270%
Mg	10.83 %	876.0 ppm	0.6565±0.04 mg/100g	142.80%	78.73%	81.36%	2850 ??

NA: Not Available

4. Conclusion

Two types of Senna plant, Cassia angustifolia and Cassia obtusifolia, were dominant in the subtropical area in central Sudan, they grow naturally in open lands. Differentiating between them done through the morphological features of their pods. Analyzing a mixture of powdered dry leaves of these two species, and comparing results with other Cassia types, had approved the wide range and the high diversity of different Senna (Cassia) types in the region.

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