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Anatomical, Proximate, Mineral and Vitamin Studies on *Celosia argentea* (Linn.)

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Authors' contributions

This work was carried out in collaboration of all authors. Author CVI designed the study. Author CC carried out the experiment and wrote the first draft of the manuscript. Authors CC and CVI managed the analyses of the study. Author CVI supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

Anatomical, Proximate, Vitamin and Mineral studies were carried out on the various parts (root, stem, leaf and petiole) of *Celosia argentea* L. using standard techniques. Analysis of variance (ANOVA) was used for the statistical analysis. Anatomical result revealed similar features in their epidermis and cortex and differences in their vascular bundles arrangement. Proximate analysis revealed that protein and fat contents were highest in the leaf (13.11±0.01%) and (10.61±0.00%) respectively. Crude fibre, ash and moisture contents were highest in the stem (20.85±0.07%), (23.91±0.02%) and (31.11±0.00%) respectively. Vitamins A and C contents were highest in leaf (9.02±0.03 µg/g) and (56.00±3.66 mg/100g) respectively. Mineral analysis showed that Zinc, phosphorus and iron contents were highest in leaf (0.82 ± 0.01 mg/100 g), (39.77±5.06 mg/100 g), (8.19±1.02 mg/100 g) respectively. This work has indicated that *Celosia argentea* is highly nutritious and should be included in our diet. Apart from the leaf eaten by our people, other parts of the plant (root and stem) should also be used as food. Also the anatomical result is an additional aid to the taxonomic characterization of the plant.

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1. INTRODUCTION

Celosia argentea L. is a leafy vegetable of the genus *Celosia,* family Amaranthaceae and order Caryophyllales [1]. It is commonly known as plumed cockscomb or the silver cockscomb. *Celosia argentea* is a herbaceous plant of tropical origin and is known for its very bright colours. The crop is produced in Nigeria by small scale farmers; solely or intercropped with arable starchy staples to produce enough food to satisfy their dietary and cash requirements. *Celosia argentea* is one of the leading leaf vegetables in South-Western Nigeria, where it is known as 'soko yòkòtò' in the Yoruba language, meaning 'make husbands fat and happy' and "eri ami onu" in Igbo, meaning as 'you eat you suck your fingers'. It is extremely important as well in Southern Benin, also popular in Togo, Ghana and Cameroon, and recorded as a vegetable from several other West and Central African Countries. Outside Africa, it occurs in tropical and subtropical Asia and America [2].

Celosia is primarily used as a leafy vegetable. The leaves, tender stems and young flower spikes are cooked into soups, sauces or stews with various ingredients including other vegetables such as onions, hot pepper and tomato, and with meat or fish and palm oil. *Celosia* leaves are tender and break down easily when cooked only briefly. The soup is consumed with the staple food of maize, rice, cassava or yam. The young inflorescences are also eaten as a potherb. It is a vegetable of high economic use. *Celosia* could also be used as an ornamental plant and as windbreaks [2].

Plant anatomy is a general term for the study of the internal structure of plants. Plant anatomy is now frequently investigated at the cellular level, and often involves the sectioning of tissues and microscopy.

Proximate analysis is a partitioning of compounds in a feed into six categories based on the chemical properties of the compounds. The six categories are: moisture, ash, crude protein, crude fat, crude fibre and nitrogen-free extracts. The body needs many minerals; these are called essential minerals. Essential minerals are sometimes divided into major minerals (macrominerals) and trace minerals (microminerals) [3]. The amounts needed in the body are not an indication of their importance.

Vitamins are organic compounds which are needed in small quantities to sustain life. We get vitamins from food, because the human body either does not produce enough of them or none at all. Vegetables and fruits are valuable components of the daily diet contributing carbohydrate in form of dietary fibre, vitamins and minerals to the body. Vitamin C or ascorbic acid is widely found in many fruits and vegetables [4]. Vitamin C is a water-soluble antioxidant known to be important to health and for proper functioning of the human body [5,6]. It prevents diseases like scurvy and also tends to control to some extent many infectious diseases, both viral and bacterial. It is also important for the healing of wounds, burns and broken bones as it is required for the synthesis of all connective tissues [7].

Leafy vegetables have been known to be very vulnerable to ascorbic acid loss [8]. Diets rich in fresh fruits and vegetables are also protective against chronic, degenerative diseases [9,10,11].

As a result of the importance of vegetables to our diet which *Celosia argentea* is inclusive, it is therefore necessary to reveal its nutritional values. This is to increase the rate of its consumption. The objectives of these studies were to determine the proximate, vitamins and amount of minerals present in *Celosia argentea* and its anatomical information as an additional aid to the plant taxonomic characterization.

2. MATERIALS AND METHODS

2.1 Area of Study and Collection and Identification of Plant Materials

The experiments were carried out at the laboratory of Plant Science and Biotechnology Department, University of Nigeria, Nsukka. The plant materials used in this work were collected between April - June from Akpo town in Aguata Local Government Area of Anambra State. The plant was identified by a taxonomist of Botany Department, Nnamdi Azikiwe University, Awka. The voucher specimen was deposited in the herbarium of Nnamdi Azikiwe University, Awka.

2.2 Anatomical Study

Anatomical study was carried out at the Anatomy Laboratory of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka

using Reichert sledge microtome. Transverse sections were made from middle part of fully grown leaves, midpoint of petiole, centre of an internode of young and mature stem and mature root. This was done using standard procedure as described by Anon [12] and Ilodibia et al. [13]. Photomicrographs of the specimens were taken with Zeiss light microscope with MC'35 Camera for 53 mm film.

2.3 Proximate, Mineral and Vitamin Studies

2.3.1 Materials and methods used

The following materials were used for the nutrients analyses: Dessicator, muffle furnace, spectrometer, silica dish, kjeldahl flask, funnel, soxhlet apparatus, filter paper, thimble, electric oven, grinder, retort stand, test tube and test tube rack, crucible, weighing balance, petri dish. The chemicals used include: Tetrahydrosulphate (vi) acid, Boric acid indicator solution, Sodium hydroxide, Hydrochloric acid, Petroleum ether, Potassium hydroxide, Acetone, Phenolphthaline indicator, Ammonia, Dithezone solution, Carbon tetrachloride, Hydroquinoline, Phenonthroline, Vanado Molybidic acid, Selenium oxide.

Proximate (ash, crude protein, crude fat, crude fibre and moisture), minerals (zinc, iron and phosphorus) and vitamins (vitamin A and C) contents were carried out to ascertain the nutrient compositions present in the plant extracts. Moisture content, total ash and protein were determined according to the method of AOAC [14]. Crude fat and carbohydrate were determined using the method of Kirk and Sawyer [15] while crude fibre was done by solvent extraction gravimetric method described by Onwuka [16]. Vitamins and minerals were done following the methods of Trease and Evans [17].

2.4 Statistical Analysis

Results were presented in mean ± standard deviation and were subjected to analysis of variance (ANOVA) using Duncan's Multiple Range Test (DMRT) at 5% probability to separate the treatments. Difference in mean value were considered significant at $P<.05$.

3. RESULTS AND DISCUSSION

Results were presented in Tables 1-3, Plates 1-5, and Figs. 1 and 2.

3.1 Anatomical Results

The transverse section of leaf of *Celosia argentea* showed that the midrib was very conspicuous and somewhat oblong to round in outline. This also revealed a uniserate epidermis, 2-3 layers of collenchyma cells and 2-3 layers of bigger parenchyma cells before the vascular bundles which were five in number, conjoint and collateral and were arranged in a semi-circular pattern. There were also smaller bundles of the veins seen (Plate 1).

The transverse section of petiole showed that the outline varies from almost circular to crescentric and somewhat flat or slightly grooved on the adaxial side. Two lateral wings were present. Immediately below the uniserate epidermis were 2-3 layer of collenchyma cell which were slightly thick walled. The vascular bundle arrangement is not similar to that of the midrib with the following variation; well defined phloem and xylem arranged in crescent manner (Plate 2).

The transverse section of root revealed that the Vascular bundles were radially arranged. The xylem and phloem elements present and conspicuous except that in the bundle, the xylem and phloem were dissected. Bundle sheath consists of several layers of thick walled sclerenchyma. It also showed uniserate epidermis followed by a wide cortex and small sized pith with medullary vascular bundles (Plate 3).

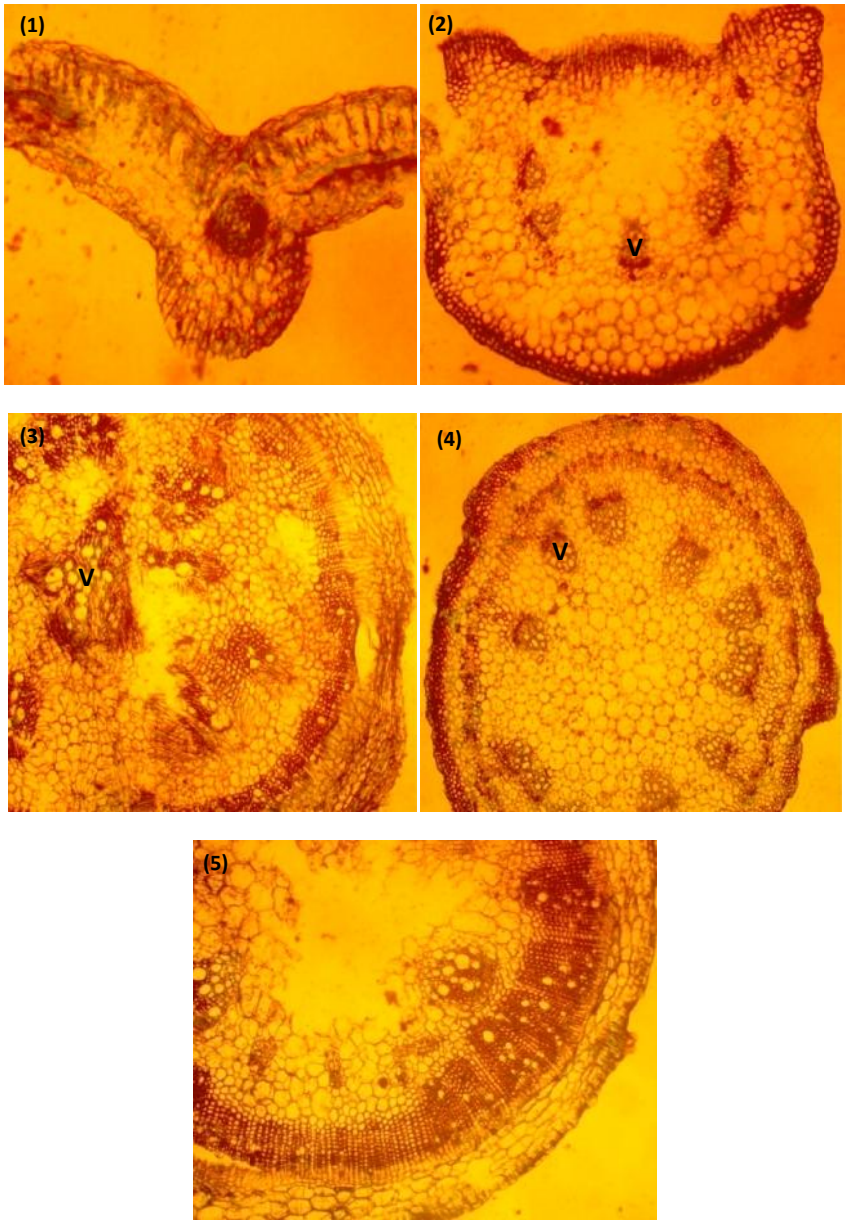
The transverse section of primary stem showed uniserate epidermis followed by collenchymatous cells which were 1-3 layers thick and 2-3 layers of parenchymatous cell. The xylem and phloem were conspicuous, conjoint and collateral with two medullary bundles at the centre. There was also presence of small pith which has some granules that may serve as water storage cells (Plate 4).

The transverse section of secondary stem revealed uniseriate epidermis, followed by 2 layered collenchyma cells, 3-4 layers parenchyma cells. This was followed by pinkish endodermis on which the vascular bundles were arranged. Secondary vascular bundles were seen. The pith was filled with parenchymatous cells which were shriveling to form a hollow at the center of the stem. The xylem and phloem are frequently and severally dissected by the formation of secondary rays (Plate 5). The result has revealed similar features in their epidermis

and cortex and differences in their vascular bundles arrangement. The result is in line with the work of a plant anatomist [18] who stated that the similarities and differences in features confirm their physiological functions as plant organs. Also, in line with the work of [19,20] who reported similar results among the various parts of *Gomphrena celosioides and Piper guineense*.

3.2 Proximate Results

Result showed that the nutrients were present in all the parts of *Celosia argentea* investigated but in varied proportions (Table 1). Protein and fat contents were highest in the leaf (13.11±0.01%) and (10.61±0.00%) respectively. Crude fibre, ash and moisture contents were highest in the stem (20.85 ± 0.07%), (23.91 ± 0.02%) and



Plates 1, 2, 3, 4, and 5. T/S of leaf, petiole, and root, primary and secondary stem respectively of *Celosia argentea*
V- Vascular bundle

Table 1. Percent (%) proximate composition of the stem, leaf and root of *Celosia argentea*

Plant Part	Proximate composition (%)				
	Crude protein	Crude fibre	Ash	Fat	Moisture
Stem	10.20±0.00[b]	20.85±0.07[c]	23.91±0.02[c]	10.09±0.01[b]	31.11±0.00[c]
Leaf	13.11±0.01[c]	8.92±0.06[a]	9.26±0.57[a]	10.61±0.00[b]	29.58±0.00[b]
Root	9.24±1.53[a]	19.34±0.90[b]	13.76±0.73[b]	5.04±0.04[a]	18.50±0.03[a]
p-value	**	**	**	**	**

*Results are mean ±SD, *Columns followed by the same letter are not significantly difference, significant difference exist at **P<.05*

(31.11 ± 0.00%) respectively (Table 1). The result has indicated that these parts are a good source of the nutrients investigated when compared to some other vegetables like Telferia occidentalis, Vernonia amygdalina [19]. The high composition of protein and fat in the leaf indicated that it can be used as food supplements especially for malnourished children and more preferably to other parts. Fat is high energy nutrient and does not add to the bulk of the diet [21]. Proteins are used for building and repairing of body tissues, regulation of body processes and formation of enzymes and hormones. The high composition of crude fibre, ash and moisture in the stem indicate the superiority of the stem as a better source of fibre, ash and moisture. Generally, 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 or azotaemia [20]. The result is in line with the work of [19,20] who reported similar results among the various parts of Gomphrena celosioides and Piper guineense and [22] who had similar results on the seed of Amaranthus species.

Analysis of the mineral composition revealed that zinc, phosphorus and iron contents were highest in the leaf (0.823±0.010, 39.768±5.060 and 8.192±1.021 respectively) (Table 2). This implies that the leaf will serve as a better source of zinc, phosphorus and iron than other parts of the plant. Iron is an important constituent of haemoglobin found in blood. Iron serves as a carrier of oxygen to the tissues from the lungs by the red blood cell haemoglobin as a transport medium for electrons within cells and as integrated part of important enzyme systems in various tissues [23]. Phosphorus is essential for the formation of bones and teeth. Formation of adenosine triphosphate ATP and synthesis of DNA and RNA while zinc is an essential trace element needed in the body for boosting the immune system and preventing lower respiratory infections [21]. The result is in line with the work of [19,20] who reported similar results among the various parts of *Gomphrena celosioides and Piper guineense*.

Table 2. Mineral composition of the stem, leaf and root of *Celosia argentea*

Plant Part	Mineral composition (mg/100 g)		
	Zinc	Phosphorus	Iron
Stem	0.52±0.00[b]	27.67±4.03[b]	3.30±3.01[a]
Leaf	0.82±0.01[c]	39.77±5.01[c]	8.19±1.02[c]
Root	0.32±0.15[a]	20.91±2.03[a]	4.88±3.21[b]
p-value	**	**	**

*Results are mean ±SD *Columns followed by the same letter are not significantly difference, significant difference exist at **P<.05*

Vitamins A and C contents were highest in the leaf (9.002±0.034 µg/g, and 56.002±3.657 mg/100g respectively) (Table 3) (Fig. 1). This implies that the leaf of *C. argentea* will serve as a better source of vitamin A and C than the root and stem. Vitamin A enhances vision and healthy skin while vitamin C activates the cell functions. Vitamin C is a powerful antioxidant. It favours the absorption of iron in the intestine, protects against infections, neutralizes blood toxins and intervenes in the healing of wounds and reduction of blood cholesterol [21]. The result is in line with the work of [19,20] who reported similar results among the various parts of *Gomphrena celosioides and Piper guineense*.

Table 3. Vitamin composition of the stem, leaf and root of *Celosia argentea*

Plant parts	Vitamin composition	
	Vitamin A (µg/g)	Vitamin C (mg/100 g)
Stem	6.08±0.02[b]	24.26±0.07[a]
Leaf	9.02±0.03[a]	56.00±3.66[b]
Root	4.14±0.23[c]	11.42±3.42[c]
P-value	**	**

*Results are mean ±SD *Columns followed by the same letter are not significantly different, significant difference exist at **P<.05*

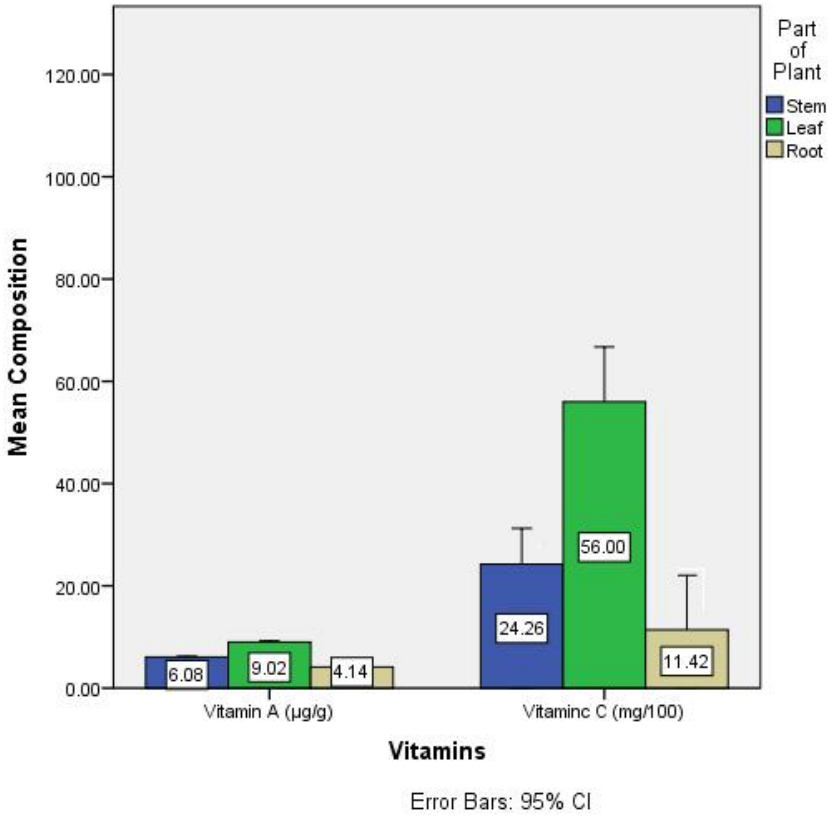


Fig. 1. Vitamin compositions of the stem, leaf and root of *Celosia argentea*

Fig. 2. Habit of *Celosia argentea*
Source: self collection

4. CONCLUSION

The study has demonstrated that *Celosia argentea* is a power house of nutrients. Apart from the leaf eaten by our people, other parts of the plant should also be used as food. The result of the study revealed that the leaf has high compositions of crude protein, fat, zinc, phosphorus, iron, vitamin A and vitamin C which indicated that *Celosia argentea* could contribute significantly to human health requirements.

Malnourished people could be advised to eat the leaves of *C. argentea* in relatively high amount as food supplement, since it is rich in proteins, minerals and vitamins (A and C).

Again, anatomical study is an additional aid to the plant taxonomic characterization and identification.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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