



Studies on Chemotaxonomic Properties of Tomato (*Solanum lycopersicum* LINN.)

*WAHUA, C; UKOMADU, J; NICHODEMUS, CO

Department Of Plant Science and Biotechnology, University Of Port Harcourt, Choba, P.M.B.5323, Nigeria

*Corresponding Author Email: chika.wahua@uniport.edu.com, Tel: +2348064043448

Other Authors Email: Josephine@uniport.edu.ng; Tel: +2348147651600; cornel4nic@gmail.com
Tel: +2348032506901

ABSTRACT: This research investigated the chemotaxonomic properties of *Solanum lycopersicum* Linn belonging to Solanaceae. The annual herbaceous free branching cultivated crop grows up to 60 cm or more in height. It has simple uniseriate trichomes densely dispersed all over the plant with adaxial and abaxial foliar trichome indices of 27.19% and 19.44% respectively. The compound leaves measure up to 6±3 cm long and 4 ± 2cm wide with serrated margin. The inflorescence has a cyme of 3 to 5 flowers or more. The petals are yellowish, up to 2±1 cm long and 1.5±0.7 cm wide with greenish sepals up to 1.5±0.7 cm long and 0.7±0.3 cm wide. Flowers are axile, hexa-pentamerous up to 1 cm in diameter with bilocular 2 celled ovary. The berry fruit is greenish when unripe and reddish when ripe, up to 5 cm in diameter with seed measuring up to 0.3 cm in diameter. The epidermal studies revealed anisocytic stomata with adaxial and abaxial stomatal indices of 19.30% and 19.64% respectively. The anatomy of mid-ribs and petioles showed bicollateral vasculature. The node is unilacunar. The stem anatomical section is made of 5 to 6 vascular bundles, with petioles associated with 2 rib traces at primary growth phase while at secondary growth phase, the mid-rib and petiole revealed vascular arcs and the stem, rings of open vascular system. Alkaloids, saponins, tannins, phlobatannins, flavonoids and combined anthraquinones were present while free anthraquinones and cardiac glycosides were absent.

DOI: <https://dx.doi.org/10.4314/jasem.v24i1.13>

Copyright: Copyright © 2020 Wahua *et al.* This is an open access article distributed under the Creative Commons Attribution License (CCL), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Dates: Received: 30 November 2019; Revised: 20 December 2019; Accepted: 23 December 2019

Keywords: Morphological, Anatomical, Cytological, Phytochemical, Studies.

Solanaceae, the egg plants family comprises 95 genera (Watson and Dallwitz, 1992; Hutchinson and Dalziel, 1958). It is widely distributed in temperate and tropical regions, but the center of distribution is Central and South America. In West Africa, there are 8 genera and 53 species of Solanaceae (Gill, 1987). *Solanum lycopersicum* Linn. is an annual plant commonly known as tomato. Stomata are considered to be one of the major epidermal structures within the leaf organ that have allowed higher plants to adapt to virtually all terrestrial environments on earth, this is made possible by means of adjustment of their size, density and distribution (Zarinkamar, 2006b). An alteration of leaf stomatal density can be used as an indicator of environmental change (Case, 2004). *Solanum roustrum*, the shrubby nightshade, is a thorny perennial with velvet leaves and stems due to dense stellate trichomes present on all over the plant (USDA, 2015). Solanaceae is predominated mostly by anomocytic stomata. Van Cotham in 1970 defined anomocytic (irregular-celled) stoma as that surrounded by a limited number of cells that are indistinguishable in size, shape, or form from those of the remainder of epidermis; anisocytic (unequaled-

celled) as stoma surrounded by three cells of which one is distinctly smaller than the other two, paracytic (parallel celled) as stoma accompanied on either side by one or more subsidiary cells parallel to the long axis of the pore and guard cells, tetracytic, as stomata with four subsidiary cells, two lateral and two terminal, and actinocytic as stoma surrounded by a circle of radially elongated subsidiary cells. *Solanum lycopersicum* Linn has simple uniseriate trichomes covering the entire plant (Purseglove, 1968). Trichomes are termed 'simple' when unbranched. Simple trichomes could be unicellular or multicellular (Metcalf and Chalk, 1979). The type of hair can be of diagnostic value at species level, sometimes also at generic level, but rarely at family level (Cutler, 1977). Trichome and stomatal complements are necessary diagnostic characters used in identification at species and generic levels and rarely at family level. The relevance of the study is to enhance information on the existing literature and taxonomic characteristics of *Solanum lycopersicum* Linn. The objective, therefore, is aimed at producing a more current and comprehensive taxonomic data involving the morphological, anatomical and phytochemical properties of *Solanum*

*Corresponding Author Email: chika.wahua@uniport.edu.com, Tel: +2348064043448

lycopersicum Linn belonging to the family Solanaceae.

MATERIALS AND METHODS

Study Area: The study area was Choba, Obio-Akpor Local Government Area of Rivers State, Nigeria.

Sample Collection: The geographic location of the parent plant studied was 040521344111N and 006⁰54¹878¹E at 18m altitude and was obtained from domesticated garden.

Epidermal Study: Fresh leaves and stem collected for this study were peeled and bleached using sodium hypochlorite for about 2 minutes following the method of Cutler (1978). The clear epidermal layers obtained were stained with Alcian blue or Safranin and temporarily mounted in aqueous glycerol solution. Photomicrographs were taken from good preparations. The method of Arnold (1973) was adopted for ascertaining stomatal length and width. The stomatal index [S.I.] was obtained using the formula:

$$\frac{S}{E+S} \times \frac{100}{1}$$

where *S* and *E* are mean numbers of stomata and epidermal cells respectively within the particular area under investigation. Likewise trichome

$$\text{Index (T.I.)} = \frac{T}{E+T} \times \frac{100}{1}$$

Where *T* and *E* are trichomes and epidermal cells respectively within the study area.

Anatomical Study: Seeds of the plant were plated in Petri dishes containing wetted 110mm Whatman filter paper. After three to five days, harvest was made for primary anatomical study and two weeks to one month, for the secondary anatomy. The harvested stems, leaves, petioles, flowers, fruits and roots were fixed in FAA in the ratio of 1:1:18 of 40% formaldehyde, acetic acid and 70% alcohol for at least 48 hours following the method of Johanson, (1978). The free hand sectioning using a systematic arrangement of 5 razor blades, as described by Wahua *et al.* (2013) was also adopted. Microphotographs were taken from good preparations using Sony camera of 7.2 Mega pixels having 2.4¹¹ LCD monitor and High sensitivity ISO 1250.

Phytochemical Study: Leaves of *Solanum lycopersicum* Linn studied were sun dried for 72 hours (3 days) and weighed. Fifty grams (50g) of the dried leaves were macerated in 96% ethanol using a pestle and a mortar. The extract was thereafter filtered and evaporated to dryness (constant weight) using a rotary

evaporator set at 45⁰C. Residue yields were noted and a portion was used for the phytochemical screening.

Phytochemical screening for saponin: Frothing tests was done following the method described by Wall *et al.* (1952). The ability of saponins to produce frothing in aqueous solution and to haemolyse red blood cells was used as screening test for these compounds. 0.5g of the plant extract was shaken with water in a test tube. Frothing which persisted on warming was taken as preliminary evidence for the presence of saponins. The disc was then washed in ether, dried and placed on a 7 percent blood nutrient agar. Complete haemolysis of red blood cells around the disc after 6 hours was taken as further evidence for the presence of saponins.

Test for alkaloids: 0.5g of the plant extract was stirred with 5ml of 1 percent aqueous hydrochloric acid on a steam bath; 1ml of the filtrate was treated with a few drops of Mayer's reagent and a second 1ml portion was treated similarly with Dragendorff's reagent. Turbidity or precipitation with either of these reagents was taken as preliminary evidence for the presence of alkaloids in the extract being evaluated (Harborne, 1973 and Trease *et al.*, 1989). A modified form of the thin-layer chromatography (TLC) method as described by Farnsworth *et al.* (1962) was used. One gram (1g) of the extract was treated with 40 percent calcium hydroxide solution until the extract was distinctly alkaline to litmus paper, and then extracted twice with 10ml portions of chloroform. The extracts were combined and concentrated in vacuo to 5ml. The chloroform extract was then spotted on thin-layer plates. Four different solvent systems were used to develop each plant extract. The presence of alkaloids in the developed chromatograms was detected by spraying the chromatograms with freshly prepared Dragendorff's spray reagent. A positive reaction on the chromatograms (indicated by an orange or darker colored spot against a pale yellow background) was confirmatory evidence that the plant extract contained alkaloid.

Test for tannins: Five grams (5g) of each portion of plant extract was stirred with 10ml of distilled water, filtered, and 5% ferric chloride reagent added to the filtrate. A blue-black, green, or blue-green precipitate was taken as evidence for the presence of tannins (Shoppee, 1964).

Test for anthraquinones: Borntrager's test was used. Five grams (5g) of each plant extract was shaken with 10ml benzene, filtered and 5ml of 10 per cent ammonia solution added to the filtrate. The mixture was shaken and the presence of a pink, red, or violet

color in the ammonia (lower) phase indicated the presence of free *hydroxyanthraquinones*.

Test for combined anthraquinones: Five grams (5g) of each plant extract was boiled with 10ml aqueous sulphuric acid and filtered while hot. The filtrate was shaken with 5ml of benzene, the benzene layer separated and half its own volume of 10 per cent ammonia solution added. A pink, red or violet coloration in the ammonia phase (lower layer) indicated the presence of anthraquinone derivatives in the extract (Trease and Evans, 1989).

Test for phlobatannins: Deposition of a red precipitate when an aqueous extract of the plant part was boiled with 1 percent aqueous hydrochloric acid was taken as evidence for the presence of phlobatannins (Trease and Evans, 1989).

Test for cardiac glycosides: Lieberman's test was used in which 0.5g of the extract was dissolved in 2ml of acetic anhydride and cooled in ice. One milliliter (1ml) of Sulphuric acid was carefully added in drops until a color change from violet to blue to green indicated the presence of a steroidal aglycone portion of the cardiac glycoside (Shoppee, 1964).

Statistical Analysis: The mean \pm standard deviation for trichome and stomatal characteristics of Solanaceae studied was done.

RESULT AND DISCUSSION

Morphological Characteristics: The plant grew up to 60cm to be in height. (Plate 1a).



Plate 1a: *Solanum lycopersicum* Linn.

The leaves are compound with ovate leaflets, densely pubescent up to 7 ± 3 cm long and 4 ± 2 cm wide with a rough or serrated margin. Petiole measured up to 1cm in length. The inflorescence has a cyme of 3 to 5 flowers together. The corolla is yellowish and up to 2 ± 1 cm in length and 1.5 ± 0.7 cm wide with a greenish

calyx and up to 1.5 ± 0.7 cm long and 0.7 ± 0.3 cm wide. Flower is penta-hexamorous and up to 1cm in diameter. (Plate 1b). Stigma is bilobed. (Plate 1c). Ovary hypogynous and superior. (Plate 1d). The fruit is a berry. Plate 1e. The brownish seed is almost spherical up to 0.3cm in length. (Plate 1f).

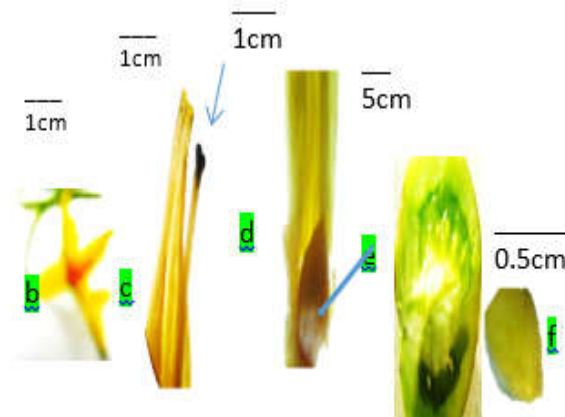


Plate 1b: *S. lycopersicum* flowers; c: Bilobed stigma, indicated by arrow in c; d: Hypogynous ovary, arrow revealed ovary in d; e: Half fruit; and f: The seed

Epidermal Study: The foliar epidermal investigation showed the presence of anisocytic stomata for both adaxial (upper) and abaxial (lower) epidermis. (Plates 2 and 3). The study revealed stomatal index of 19.30% for adaxial layer and 19.64% stomatal index for the abaxial surface. The trichomes were simple uniseriate forms which showed trichome index of 27.19% for the adaxial surface and trichome index of 19.44% for the abaxial layer. The stem epidermal layer also revealed anisocytic stomata and uniseriate trichomes. (Plate 4).

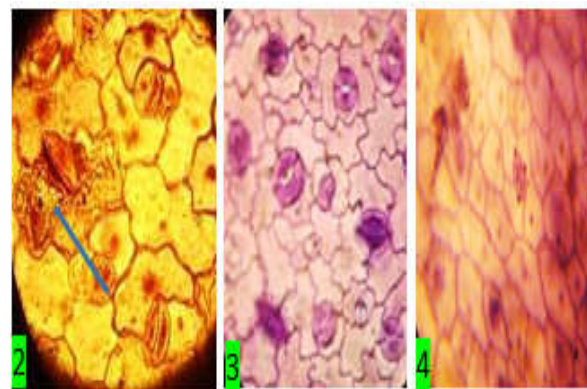


Plate 2: Adaxial epidermal layer. **Plate 3:** Abaxial epidermal layer. **Plate 4:** Stem epidermal layer. Arrow showcased contiguous cells in *Solanum lycopersicum* Linn. adaxial epidermis. Stem epidermal cells nucleated.

Anatomical Study: The mid-ribs and petioles anatomical sections showed Bicollateral vascular system. There were 3 vascular traces and the petioles were associated with 2 rib traces at primary growth

while the secondary phase revealed vascular arcs. (Plate 5). The mid-rib showed a roll of epidermal cells. Collenchymatous cells occupied the region of the hypodermis, the general cortex was predominated by parenchymatous cells. Three vascular traces with no rib bundle wings were revealed in the primary growth phase. The endodermoid layer is made of a layer of barrel-shaped cells. The pericycle is multilayered. The pith region is made of large parenchymatous cells. (Plate 6). The stem had rings of open vascular system. (Plate 7). The node is unilacunar. (Plate 8).

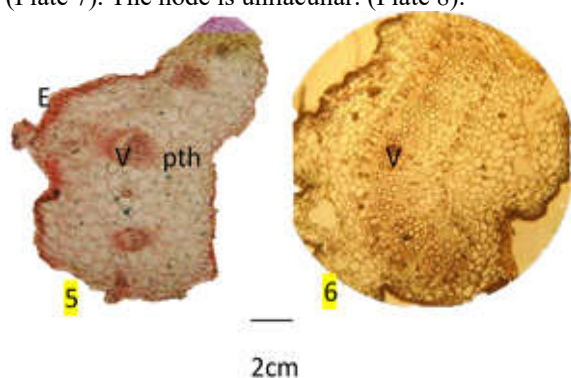


Plate 5: The petiole anatomy; **Plate 6:** The mid-rib anatomy; E represents epidermis; v for vascular bundle and pth for pith.

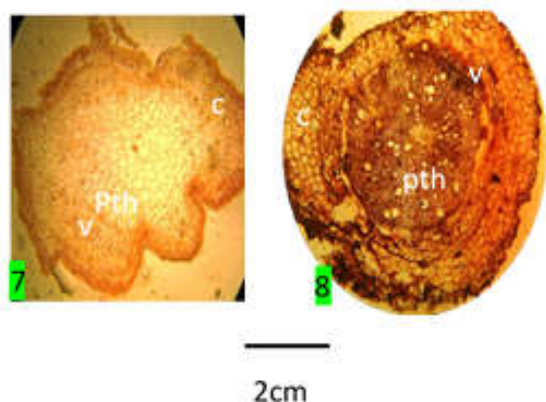


Plate 7: The stem anatomy; **Plate 8:** The nodal anatomy; Pth. showed the position of the pith. V represents the vascular system, C showed the general cortex of *Solanum lycopersicum* Linn.

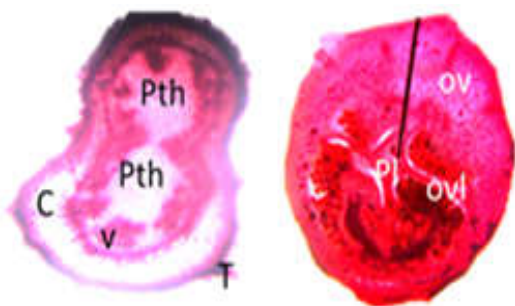


Plate 9: The root anatomy. **Plate 10:** The flower placentation, pl represents placenta; pth. revealed the pith, T represents the trichome, C – the general cortex, Ovl represents the ovule and ovl for ovary of *Solanum lycopersicum* Linn. Pl or Arrow revealed placenta. *S. lycopersicum* Linn. is a bisexual or hermaphrodite.

The root anatomy revealed a layer of piliferous cells below which is the multilayered general cortex surrounding the xylary cells and a central pith occupied with parenchymatous cells. The vascular bundles were radially symmetrical. (Plate 9). The ovary anatomy revealed the placentation as axile type. Ovary was trilocular and 3-celled. (Plate 10).

Phytochemical Studies: Qualitative analyses carried out revealed the presence of the following phytochemical constituents: Alkaloids, saponins, tannins, phlobatannins, flavonoids and combined anthraquinones as present while free anthraquinones and cardiac glycosides were absent.

Conclusion: *Solanum lycopersicum* Linn is a fruity vegetable and is domesticated for its medicinal and commercial purposes. Researches in the morphological, anatomical, cytological and phytochemical properties have in one way or the other improved up on the existing knowledge on *Solanum lycopersicum* Linn. Areas of future interest are: Palynology, proximate analysis and quantitative aspect of phytochemistry.

Acknowledgement: The author acknowledges with thanks, the contributions of Prof. B. E. Okoli of Plant Science and Biotechnology, Faculty of Science, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria, now retired.

REFERENCES

- Arnold, E. (1973). *Peacock's Elementary Microtechnique*. Pitman Press, Bath, Great Britain. Pp. 12-16.
- Cutler, D. F. (1977). *Applied Plant Anatomy* Longman-Group Limited London.
- Cutler, D. F. (1978). *Applied Plant Anatomy* .Lib. Congr. Cataloguing in Publication Data. William Clowes and Sons Ltd London.
- Farnsworth, N. R. and Euer, K. L. (1962). Alkaloid screening procedure utilizing thin-layer chromatograph. *Lloydia*. 25-186.
- Fatemeh Zarinkamar, (2007). Stomatal Observations in Cotyledons. *Pakistan Journal of Biological Sciences*, 10:199-219
- Harborne, J. B. (1973). *Phytochemical Methods A Guide to Modern Techniques of Plant Analysis*. Chapman & Hall, London. 279 pp.

- Johansen H. (1940). *Plants Microtechnique*. McGraw-Hill, New York. 532 pp.
- Okoli, B. E. (1983). Hybridization, polyploidy and apomixes in *Andropogon tectorum* *New Phytol* 93:591-597.
- Shoppee, C. W. (1964). *Chemistry of the Steroids*, 2nd edn. Butterworths, London.
- Trease, G. E and Evans, W. C.(1989). *A. Text Book of Pharmacognosy*. 3rd eds. Boilliere Tinall Ltd., London.
- United States Data Base (2015): *robustrum* Natural Resource Conservation Service. PLANTS Database, SDA. Retrieved 17 November, 2015.
- Wahua, C., Okoli, B.E. and Sam, S. M. (2013). Comparative morphological, anatomical, cytological and phytochemical studies on *Capsicum frutescens* Linn and *Capsicum annum* Linn. (Solanaceae). *Int. Journal for Scientific and Engineering Research*. 4 (1): 1-20.
- Wall, M. E, Eddy, C. R. McClenna, M. L; Klump, M. E. (1952). Detection and estimation of steroids apogeninin plant tissues. *Anal Chem*. 24, 1337