Short communication

Effect of season on the nutritional components of *Spathodea campanulata* Beauv

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Abstract

Objective: To evaluate the nutritional composition of the different organs of *Spathodea campanulata* Beauv. In the two seasons of the year, for its use as alternative feedstuff in the animal production systems in Cuba.

Materials and Methods: The trial was conducted in the Institute of Animal Science, during the months March-April (dry season) and August-September (rainy season). Samples of ten plants were collected and their different organs were separated to determine the protein content, mineral composition and fiber fractioning. An analysis was carried out, where the seasons of the year and the plant organs were considered as factors. The differences among means were compared by Duncan's test and the statistical program Infostat® was used.

Results: Interaction ($p < 0,001$) of the season with the plant components was found for the ash, macroelements, protein and fiber fractioning. The highest protein concentrations were reached in the dry season and the highest values were found in the leaves and young plant (16,9 and 15,7 %, respectively). The cell wall components showed an opposite performance and the highest values were recorded in the rainy season (60,59; 46,20; 81,57; 59,73 % of dry matter).

Conclusions: The nutritional composition shows high content of chemical compounds, which constitute essential nutrients for the animal metabolism, which proves the potential of the species *S. campanulata* for its use as alternative feedstuff in animal production systems.

Keywords: chemical composition, African tulip

Introduction

Invasive species constitute a great threat for the environment and for the economy of any country (Nghiem *et al*., 2015). *Spathodea campanulata* Beauv. is a wild plant that belongs to the family Bignoniaceae (Begum *et al*., 2020). It is commonly known as African tulip or Nandi flame. It is considered among the most deleterious 100 invasive exotic species of the world, for which it affects the ecosystems of many regions (Tanayen *et al*., 2016).

This plant is distributed along the western African coast, from the Republic of Ghana to Angola and, inland, it crosses the humid center of the continent to the south of Sudan and Uganda. Beyond its natural area of distribution, it has become naturalized in Colombia, Costa Rica, Puerto Rico and Cuba (Sutton *et al*., 2017).

According to Muñoz-Labrador (2016), in Cuba it is distributed throughout the country, mainly in the central region. In the mountainous ecosystems of the Guamuhaya mountain range, located at the center of the island, a group of exotic species was reported, present in coffee plantations and forest areas which, due to their high presence and invasion capacity, could become invasive species of these ecosystems, among them is *S. campanulata* (Herrera-Isla *et al*., 2015).

The flowers of the African tulip are among the most beautiful of African trees, for which they are highly used as ornamental plant (Villareal *et al*., 2017). It is recommended as a shade tree for parks and yards, although it is also used as living fence (Damaiyani *et al*., 2018).

This plant is object of research in traditional and natural medicine due to its different properties, derived from its secondary metabolism (Boniface, 2017). Wagh and Butle (2018) and Santos *et al.* (2020) indicated, among others, anti-inflammatory, antimicrobial and antioxidant properties of this species.

At present, it is a priority for researchers of the agricultural sector to evaluate species that do not have any use, and to widen the usefulness of those that normally have other purposes, for their utilization in

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animal feeding. In Cuba there is little information about the nutritional quality of this species, for its utilization as livestock feedstuff. The objective of this work was to evaluate the nutritional composition of the different organs of *S. campanulata* in the two seasons of the year, for its use as alternative feeding in animal production systems.

Materials and Methods

Location and soil condition. The experiment was conducted in the Institute of Animal Science (ICA, for its initials in Spanish), located at 22°81' North latitude and 82°01' West longitude, in San José de las Lajas, Mayabeque province (Academia de Ciencias de Cuba, 1989). The soil is moderately acid and is classified as hydrated Ferralitic Red (Hernández-Jiménez *et al*., 2015).

Experimental procedure. In ten adult plants, from a pastureland of the ICA, the organs (leaves and stems) were separated and the rest was used as integral plant (leaves plus fresh stems), like the young plants. The samples, previously homogenized, were dried at room temperature in a ventilated facility of the research shed of the department of monogastric animals, during five days. The samples were ground in a hammer mill, to a particle size of 1 mm. The meals (adult whole plant, leaves, stems and young whole plant) were stored in amber glass flasks for their later analysis.

Samplings. Two samplings were performed per season, in August-September, for the rainy season and in March-April for the dry season. Ten young shrubs, with height of 5-7 m, and 10 adult trees, with height between 10 and 13 m, were randomly sampled, which constituted each one of the samples.

Bromatological analysis. The residual dry matter (RDM), crude protein (CP) and ash (Ash) were determined according to AOAC (2006).

Mineral composition. The macro- and microelements were analyzed by spectrophotometry of atomic absorption, according to the procedures of the data book (Atomic Absortion Data, 1991). The analysis was carried out in a Philips piece of equipment of the firm Pye Unicam, with series number PV 9100. The height of the burner was 10 mm. The gas composition was air-acetylene, and the flow was 4,5 mm/min. The phosphorus determination was done according to the methodology proposed by Amaral (1972).

Fiber fractioning. The neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (Lig) and cellulose (Cel) were determined according to the procedure described by Goering and Van Soest (1970).

Statistical analysis. A variance analysis was carried out after testing the variance homogeneity and normality assumptions. In addition, the seasons of the year (rainy and dry) and the plant organs (adult whole plant, leaves, stems, young whole plant) were considered as factors. The differences among means were contrasted through Duncan's multiple comparison test and the statistical program Infostat® (Di Rienzo *et al*., 2012) was used.

Results and Discussion

Table 1 shows the effect of season on the chemical indicators RDM, Ash, macroelements (Ca, Mg, K, P) and CP of the meals from the different organs of *S. campanulata*. Interaction was observed between the factors season of the year (rainy and dry) and plant organs (leaves, stems), adult whole plant and young whole plant.

The RDM and Ash contents differed among the organs, the adult and young plants. The RDM oscillated between 87,2 and 90,0% DM. the lowest value ($p < 0,0257$) was recorded in the young plant in the rainy season. Meanwhile, the highest Ash values were obtained in the leaves in the dry season.

In the rainy season the highest Ca concentrations were reached in the leaves of adult plants. Whereas, in the dry season, the highest Mg and P values ($p < 0,001$) were recorded in the leaves and the young plant.

K showed a similar performance to P. The young plant reached the highest concentrations ($p = 0,0001$) in the dry season; while in the stem there were no differences according to the climate seasons.

In the dry season, the protein concentrations in the adult plant, the leaves and young plant were increased with regards to the rainy season. The leaves were the ones that reached the highest ($p < 0,05$) protein values. Nevertheless, in the stems no differences were found between the evaluated seasons.

The determination of the DM content of a forage plant is essential for a correct evaluation of the content of other chemical constituents. When the DM values are very low, the moisture content is higher, which allows microbiological changes associated to bacteria, fungi and yeasts, for which there is risk that the feedstuff is deteriorated and its innocuousness is affected. The DM contents found in this experiment were higher than those reported by Aregheore and Siasau (2008) in Samoa for plants of this same species.

Table 1. Performance of the chemical indicators residual dry matter, ash, minerals and protein of *S. campanulata* in the rainy and dry seasons (%).

Indicator	Season	Adult plant	Leaves	Stems	Young plant	SE ±	P - value
RDM	Dry season	89,0^{bc}	90,0^{d}	89,3b^{dc}	88,0^{a}	0,260	0,0257
	Rainy season	89,8^{de}	89,8^{de}	88,7^{bc}	87,2^{a}		
Ash	Dry season	13,0^{c}	15,8^{d}	6,5^{a}	9,2b	0,310	<0,0001
	Rainy season	9,6^{b}	11,2^{c}	6,1^{a}	11,7^{c}		
Ca	Dry season	3,5^{d}	3,6^{d}	1,4^{b}	0,5^{a}	0,080	<0,0001
	Rainy season	2,5^{b}	3,8^{c}	1,4^{a}	1,5^{a}		
Mg	Dry season	0,8^{b}	1,7^{c}	0,4^{a}	0,8^{b}	0,020	0,0001
	Rainy season	0,2^{a}	0,4^{c}	0,25^{ab}	0,3^{b}		
K	Dry season	0,9^{b}	0,6^{a}	1,02^{c}	2,26^{d}	0,030	0,0001
	Rainy season	1,0^{b}	0,9^{a}	1,0^{b}	1,3^{c}		
P	Dry season	0,4^{c}	0,3^{a}	0,3^{b}	0,6^{d}	0,004	0,0001
	Rainy season	0,2^{b}	0,3^{c}	0,2^{a}	0,3^{e}		
CP	Dry season	12,6^{b}	16,9^{d}	6,3^{a}	15,7^{c}	0,190	0,0002
	Rainy season	10,8^{b}	15,3^{e}	6,5^{a}	14,2^{d}		

a, b, c, d, e, f. Different letters in the same row differ for $p < 0,05$
RDM: residual dry matter, CP: crude protein

According to Lugo *et al.* (2011), Ash is an indicator of the proportion of inorganic compounds in the plant, and allows the estimation of the organic matter present. The Ash values in leaves and stems were higher (9,2 and 2,0 %, respectively) than the ones reported in *S. campanulata* samples, collected in Puerto Rico.

García *et al.* (2008) reported Ash values in the range of 4,3-21,7 % for forage plants widely used in animal feeding, for which the values found in this work are found in that range, because they were between 6,1 and 15,8 %.

The mineral content of plant tissues is variable, and depends, among other factors, on the plant type, soil chemical composition, environment and tissue age (Raven *et al.*, 1992). The differences shown by macroelements between the studied experimental periods can be associated to the losses of soluble minerals in the rainy season.

Bla *et al.* (2016), when evaluating the mineral composition of *S. campanulata* in plants cultivated in Africa found in the leaves values for Ca, P and Mg of 71,6; 33,6 and 73,6 ppm, respectively. These results are lower than the ones obtained here in the two analyzed seasons. The differences can be related to the variations in the edaphoclimatic conditions.

CP, like others chemical composition indicators, varies according to the parts of the plant that are harvested and its phenological status. In this study, the differences shown by protein between the plant organs can be ascribed to the increase of the synthesis of protein compounds in the leaves, due to the activity that these organs perform in the synthesis of carbohydrates and other substances that integrate the plant. The decrease of CP concentration in the rainy season (with the exception of the stem) can be related to an effect of nitrogen dilution, when increasing the biomass accumulation due to the favorable conditions of light, temperature and humidity in this season (Muñoz-González *et al.*, 2016).

The CP values for the leaves and young plant, in both seasons, exceeded 14,0 %, and are higher than those reported (13,1 and 9,0 % DM) by Cabrera-Núñez *et al.* (2019) in other species of the family Bignoniaceae. Thus, this plant could be an alternative to contribute with the protein requirements of animals, mainly in the dry season, when feed is scarcer.

Concerning the cell wall components, interactions were also found between treatments and season (table 2).

Table 2. Performance of the chemical indicators of *S. campanulata* in the rainy and dry seasons (%.)

Indicator	Season	Adult plant	Leaves	Stems	Young plant	SE ±	P - value
NDF	Dry season	45,1[b]	42,6[a]	71,4[c]	45,9[b]	0,710	0,0001
	Rainy season	60,6[a]	46,2[b]	81,6[c]	59,7[a]		
ADF	Dry season	34,9[b]	28,5[a]	58,2[d]	43,9[c]	0,590	0,0001
	Rainy season	53,1[b]	40,9[a]	65,3[d]	54,8[c]		
Lig	Dry season	13,5[b]	12,5[a]	13,9[b]	13,8[b]	0,280	0,0223
	Rainy season	7,4[a]	7,1[a]	9,2[b]	9,6[b]		
Cel	Dry season	20,9[b]	15,0[a]	43,8[d]	30,1[c]	0,350	0,0001
	Rainy season	45,0[b]	32,4[a]	54,1[c]	44,9[b]		

a, b, c, d, e, f. Different letters in the same row differ for p < 0,05

NDF: neutral detergent fiber, ADF: acid detergent fiber, Lig: lignin and Cel: cellulose

It was observed that the NDF and ADF differed between the two seasons of the year for the meals of the adult plant, leaves, stems and young plant. The highest values (p < 0,0001) were reached in the stems in the rainy season (81,6 and 65,3 %, respectively). Similar performance was shown by lignin and cellulose with regards to the season in all the fractions. However, the lignin concentration was similar for the adult plant, stems and young plant in the dry season.

In this study higher content of NDF and ADF was observed in the rainy season. These results can be related to the performance of climate factors in each seasonal period. The rainy one is the season with higher temperatures, solar radiation, duration of light and rainfall, for which plant growth and development is higher. From the metabolic point of view, there are propitious conditions for carbohydrate production from photosynthesis, for which the cell wall content increases, and plant digestibility is reduced (Herrera *et al*., 2017).

In this experiment, the lignin values were higher than the ones obtained by Alatorre-Hernández *et al*. (2018) in tropical legumes. Yet, they could be overestimated, because tannins bind to the fiber and can cause the overestimation of its contents. This aspect was proven in a study conducted by Pérez (2017) in different organs of *S. campanulata*. This author found high concentrations of condensed tannins, bound to the ADF and NDF, in the two seasons. The biosynthesis and deposition of lignin in the cell wall of the plant can also be increased when the plant is subject to some stress, like the one that can be caused by birds and other herbivore animals, because it is considered an important defense mechanism (Lagunes-Fortiz and Zavaleta-Mejía, 2016).

The fibrous fraction of plants is one of the indicators that can limit their voluntary intake by the animals. In order to include the forages from this plant in the feeding of the different animal species, the chemical composition of its fibrous fraction is not sufficient, but it is necessary to study its physical properties. According to Savón (2010), this indicator contributes to determining the quality of fibrous feedstuffs and to predict their effects on the gastrointestinal functions of the animal organism.

Another essential aspect for recommending this species as feedstuff for animals is the study of secondary metabolites, because the presence of some of these compounds can affect the efficient utilization of nutrients in the animals. Nevertheless, Scull (2018) indicates that the antinutritional or beneficial effects of secondary compounds depend on their concentration, chemical structure and bioavailability, as well as on the animal species and its characteristics.

Conclusions

The results of this research indicate high content of chemical compounds, which constitute essential nutrients for animal metabolism, which proves the nutritional potential of the species *S. campanulata* for its use as alternative feedstuff in animal production systems. However, it is necessary to conduct future research in order to determine the effect of this plant on the different animal species.

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Authors' contribution

- Idania Scull-Rodríguez. Design and setting up of the research, data analysis and interpretation, manuscript writing and revision.
- Arabel Elías-Iglesias†. Research design.
- Dairon Pérez-Fuentes. Research conduction, data processing and manuscript writing.
- Lourdes Lucila Savón-Valdés. Research supervision and manuscript revision.
- Magalys Herrera-Villafranco. Methodology design and statistical analysis of the data.
- Natacha Pompa-Castillo. Research conduction and data processing.

Conflicts of interests

The authors declare that there is no conflict of interests among them.

Bibliographic references

Academia de Ciencias de Cuba. *Nuevo Atlas Nacional de Cuba*. La Habana: Instituto Cubano de Geodesia y Cartografía, 1989.

Alatorre-Hernández, A.; Guerrero-Rodríguez, J. de D.; Olvera-Hernández, J. I.; Aceves-Ruiz, E.; Vaquera-Huerta, H. & Vargas-López, S. Productividad, características fisicoquímicas y digestibilidad *in vitro* de leguminosas forrajeras en trópico seco de México. *Rev. Mex. Cienc. Pecuarias*. 9 (2):296-315, 2018. DOI: https://doi.org/10.22319/rmcpv9i2.4361.

Amaral, A. *Técnicas analíticas para evaluar macro nutrientes en cenizas de caña de azúcar. Laboratorio de nutrición de la caña*. La Habana: Escuela de Química, Universidad de La Habana, 1972.

AOAC. *Official methods of analysis*. 20th ed. Arlington, USA: AOAC International, 2006.

Aregheore, E. M. & Siasau, M. Nutritive value and voluntary feed intake of African tulip (*Spathodea campanulata*) and lemon (*Citrus limon*) foliage as supplements in untreated and urea treated maize stover diets by growing goats. *Sci Agric. Bohem*. 39 (4):318-323. https://sab.czu.cz/dl/44576?lang=en, 2008.

Atomic Absorption Data. *A scientific and industrial company of Philips*. Cambridge, UK: Pye Unicam, 1991.

Begum, A.; Biswas, P. & Shahed-Al-Mahmud, Md. Methanol extract of *Spathodea campanulata* P. (Beauv.) leaves demonstrate sedative and anxiolytic like actions on swiss albino mice. *Clin. Phytosci*. 6 (41):2-12, 2020. DOI: https://doi.org/10.1186/s40816-020-00182-z.

Bla, B. K.; Koffi, J. A.; Silue, D. K.; Houphouët, F. & Djaman, J. A. Determination of mineral elements and crude protein of eight medicinal plants from Central Côte D'ivoire. *International Journal of Sciences*. 5 (02):63-69, 2016. DOI: https://doi.org/10.18483/ijSci.946.

Boniface, P. K. Advances on ethnomedicinal uses, phytochemistry, and pharmacology of *Spathodea campanulata* P. Beauv. *EC Pharmacol. Toxicol*. 5 (2):51-62, 2017.

Cabrera-Núñez, Amalia; Lammoglia-Villagomez, M.; Alarcón-Pulido, Sara; Martínez-Sánchez, C. & Rojas-Ronquillo, Rebeca. Árboles y arbustos forrajeros utilizados para la alimentación de ganado bovino en el norte de Veracruz, México. *Abanico Vet*. 9:1-12, 2019. DOI: https://doi.org/10.21929/abavet2019.913.

Damaiyani, J.; Purwestri, Y. A. & Sumardi, I. The orbicules and allergenic protein of African tulip tree (*Spathodea campanulata* P. Beauv.): a roadside ornamental plant in Malang, Indonesia. *Journal of Biological Researches*. 24 (1):43-46. http://lipi.go.id, 2018. DOI: https://doi.org/10.23869/bphijbr.24.1.20186.

Di-Rienzo, J. A.; Casanoves, F.; Balzarini, Mónica G.; González, Laura A.; Tablada, M. & Robledo, C. *InfoStat versión 2012*. Córdoba, Argentina: Grupo InfoStat, FCA, Universidad Nacional de Córdoba. http://www.infostat.com.ar, 2012.

García, D. E.; Medina, María G.; Cova, L. J.; Torres, A.; Soca, Mildrey; Pizzani, P. *et al.* Preferencia de vacunos por el follaje de doce especies con potencial para sistemas agrosilvopastoriles en el Estado Trujillo, Venezuela. *Pastos y Forrajes*. 31 (3):255-270. http://www.scielo.cu/scielo.php?script=sci_arttext&pid=S0864-03942008000300006&lng=es&nrm=iso, 2008.

Goering, H. & Van Soest, P. J. *Forage fiber analysis (Aparatus, reagents, procedures and some appications)*. Washington: USDA. Agricultural Handbook No. 379, 1970.

Hernández-Jiménez, A.; Pérez-Jiménez, J. M.; Bosch-Infante, D. & Castro-Speck, N. *Clasificación de los suelos de Cuba 2015*. Mayabeque, Cuba: Instituto Nacional de Ciencias Agrícolas, Instituto de Suelos, Ediciones INCA, 2015.

Herrera, R. S.; Verdecia, D. M.; Ramírez, J. L.; García, M. & Cruz, Ana M. Relation between some climatic factors and the chemical composition of *Tithonia diversifolia*. *Cuban J. Agric. Sci*. 51 (2):271-279. http://www.cjascience.com/cjas13217.pdf, 2017.

Herrera-Isla, L.; Grillo-Ravelo, H.; Harrigton, T.; Díaz-Medina, A. & Álvarez-Puente, R. *Ceratocystis fimbriata* Ellis & Halst. f. sp. Spathodense (nueva especialización): agente causal de la marchitez en *Spathodea campanulata* Beauv. en Cuba. *Rev. Protección Veg.* 30 (1):40-45. http://www.scielo.cu/scielo.php?script=sci_arttext&pid=S1010-27522015000100007&lng=es&lng=iso, 2015.

Lagunes-Fortiz, Erika & Zavaleta-Mejía, Emma. Función de la lignina en la interacción planta-nematodos endoparásitos sedentarios. *Rev. Mex Fitopatol*. 34 (1):43-63, 2016. DOI: https://doi.org/10.18781/R.MEX.FIT.506-7.

Lugo, A. E.; Abelleira, O. J.; Collado, A.; Viera, C. A.; Santiago, Cynthia; Vélez, D. O. *et al.* Allometry, biomass, and chemical content of novel African tulip tree (*Spathodea campanulata*) in Puerto Rico. *New Forests*. 42:267, 2011. DOI: https://doi.org/10.1007/s11056-011-9258-8.

Muñoz-González, J. C.; Huerta-Bravo, M.; Lara-Bueno, A.; Rangel-Santos, R. & Rosa-Arana, J. L. de la. Production and nutritional quality of forages in conditions Humid Tropics of Mexico. *Rev. Mex. Cienc. Agríc*. 7 (spe 16):3315-3327. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-09342016000123315&lng=es&nrm=iso, 2016.

Muñoz-Labrador, Y. J. *Vegetación forestal en áreas aledañas al puente del vial Colón, ciudad Pinar del Río*. Tesis para la obtención del título de Ingeniero forestal. Pinar del Río, Cuba: Universidad de Pinar del Río, 2016.

Nghiem, L. T. P.; Tan, H. T. W. & Corlett, R. T. Invasive trees in Singapore: are they a threat to native forests? *Trop. Conserv. Sci*. 8 (1):201-214. http://www.tropicalconservationscience.org, 2015.

Pérez, D. *Determinación de componentes nutricionales y fitoquímicos de plantas silvestres Spathodea campanulata*. Tesis de diploma en opción al título de Licenciado en Química. La Habana: Universidad de La Habana, 2017.

Raven, P. H.; Evert, R. F. & Eichhorn, Susan E. *Biología de las plantas*. (S. Santamaría, F. Lloret y M. Mas, eds.). Barcelona, España: Editorial Reverté S.A, 1992.

Santos, V. E. M. dos S; Minatel, I. O.; Lima, Giuseppina P. P.; Silva, R. M. G. & Chen, C.-Y. O. Antioxidant capacity and phytochemical characterization of *Spathodea campanulata* growing in different climatic zones in Brazil. *Biocatal. Agric. Biotechnol*. 24:101536, 2020. DOI: https://doi.org/10.1016/j.bcab.2020.101536.

Savón, Lourdes L. *Harina de forrajes tropicales. Fuentes potenciales para la alimentación de especies monogástricas*. Tesis en opción al grado de Doctor en Ciencias Veterinarias. San José de las Lajas, Cuba: Instituto de Ciencia Animal, 2010.

Scull, Idania. *Caracterización química de la harina de forraje de* Mucuna pruriens *(L) D. vc. utilis (Wall. Ex Wight) L. H. Bailey y su evaluación como antioxidante natural para la alimentación animal*. Tesis en opción al grado de doctor en Ciencias Veterinarias. Mayabeque, Cuba: Instituto de Ciencia Animal, 2018.

Sutton, G. F.; Paterson, L. D. & Paynter, Q. Genetic matching of invasive populations of the African tulip tree, *Spathodea campanulata* Beauv. (Bignoniaceae), to their native distribution: Maximising the likelihood of selecting host-compatible biological control agents. *Biological Control*. 114:167-175, 2017. DOI: https://doi.org/10.1016/j.biocontrol.2017.08.015.

Tanayen, J. K.; Ezeonwumelu, J. OC; Ajayi, A. M.; Oloro, J.; Tanayen, Grace G.; Lonzy, O. *et al.* Evaluation of the acute and sub chronic toxicities of the methanolic stem bark extract of *Spathodea campanulata* (P. Beauv.) Bignoniaceae. *Br. J. Pharmacol. Toxicol*. 7 (1):9-19, 2016. DOI: https://doi.org/10.19026/_bipt.7.2804.

Villarreal, Silvana; Moreno, Sindy; Jaimez, Deisy; Rojas-Fermín, L. B.; Lucena-Escalona, María E.; Díaz, Lorena *et al.* Actividad antibacteriana y antioxidante de extractos crudos de plantas pertenecientes a la familia Bignoniaceae. *Acta Bioclin*. 7 (14):205-222. http://erevistas.saber.ula.ve/index.php/actabioclinica/artcle/8354-26743-2-PB, 2017.

Wagh, Anita S. & Butle, S. R. Plant profile, phytochemistry and pharmacology of *Spathodea campanulata* P. Beauvais (African tulip tree): A review. *Int. J. Pharm. Pharm. Sci*. 10 (5):1-6, 2018. DOI: https://doi.org/10.22159/ijpps.2018v10i5.24096.