Article **ECORFAN Journal-Ecuador**
June 2020 Vol.7 No.12 23-33

Chemical composition of *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae) and diversity of uses in rural areas

Composición química de *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae) y diversidad de usos en el medio rural

ROMÁN-MIRANDA, María Leonor´†, MORA-SANTACRUZ, Antonio´, AVENDAÑO-LÓPEZ, Adriana Natividad*´´ and SÁNCHEZ-MARTÍNEZ, José´´

Universidad de Guadalajara. University Center for Biological and Agricultural Sciences.
´Department of Forest Production.
´´Department of Agricultural Production.

ID 1st Author: *María Leonor, Román-Miranda* / **ORC ID:** 0000-0002-9420-2150, **Researcher ID Thomson:** T-4608-2018, **CVU CONACYT ID:** 264122

ID 1st Co-author: *Antonio, Mora-Santacruz* / **ORC ID:** 0000-0002-6169-2077, **Researcher ID Thomson:** T-4708-2018, **CVU CONACYT ID:** 96712

ID 2nd Co-author: *Adriana Natividad, Avendaño-López* / **ORC ID:** 0000-0003-1713-1165, **Researcher ID Thomson:** X-11052018, **CVU CONACYT ID:** 238209

ID 3rd Co-author: *José, Sánchez-Martínez* / **ORC ID:** 0000-0002-1451-1149, **Researcher ID Thomson:** X-1133-2018, **CVU CONACYT ID:** 63408

DOI: 10.35429/EJE.2020.12.7.23.33 Received January 10, 2020; Accepted June 30, 2020

Abstract

The objective of this study was to evaluate the nutritional quality of *Tithonia diversifolia*, a shrub species in the Asteraceae family and the diversity of uses in rural areas. A bibligraphic review was conducted in Mexico and other countries in Central America, South America, Africa and Asia. Bromatological analyses of edible material (leaves and petiole) were performed to determine dry matter (DM), fat, ash, crude fiber, crude protein (CP), and nitrogen-free-extract (NFE). Fiber fractions were determined: neutral deterget fiber (FDN), acid detergent fiber (ADF), hemicellulose, cellulose and lignin, from two locations in Jalisco state and one from Colima. Herbarium specimens were reviewed for knowing geographical distribution and rural uses. Results indicate that even without being legume, CP percentages are high with values of 18.42 to 31.54% with high dry matter content up to 98.92%, fiber values (30.81 to 34.08%) for NDF and (22.48 to 31.69%) for ADF. The bibliographic review highlights its forgae use, for ruminants and monogastrics, in beekeeping for its content of néctar and pollen, sucha as medicinal, ornamental and green manure for its contribution of nutritious, mainly phosphorus. *T. diversifolia* is a good option for its nutritional value and diversity of uses are demonstrated as an alternative in semi-intensive animal production systems in both tropical and temperate áreas.

Beekeeping, Crude protein, Dry matter, Fiber fractions, Medicinal use

Resumen

El objetivo de este estudio fue evaluar la calidad nutritiva de *Tithonia diversifolia*, especie arbustiva de la familia Asteraceae y la diversidad de usos en áreas rurales. Se realizó una revisión bibliográfica en México y otros países de Centroamérica, Sudamérica, África y Asia. Se realizaron análisis bromatológicos de material comestible (hojas y pecíolo), para determinar materia seca (MS), grasa, cenizas, proteína cruda (PC), fibra cruda (FC) y extracto libre de nitrógeno (ELN). Se determinó fracciones de fibra: fibra detergente neutro (FDN), fibra detergente acido (FDA), hemicelulosa, celulosa y lignina de plantas, procedentes de dos localidades del estado de Jalisco y una del estado de Colima. Asimismo, se revisaron ejemplares de herbarios para conocer su distribución geográfica y los usos en el medio rural. Los resultados indican que aún sin ser leguminosa los porcentajes de PC son altos con valores de 18.42 a 31.54%, con alto contenido de materia seca hasta de 98.92%, valores de fibra de (30.81 a 34.08%) para (FDN) y de (22.48 a 31.69%) para (FDA). La literatura resalta su uso forrajero, para rumiantes y monogástricos, en la apicultura por su contenido de néctar y polen, como medicinal, ornamental y abono verde por su aporte de nutrimentos, principalmente fósforo. *T. diversifolia* es una buena opción, ya que se demuestra su valor nutritivo y la diversidad de usos, como una alternativa en sistemas semi-intensivos de producción animal, tanto en zonas tropicales como zonas templadas.

Apicultura, Fracciones de fibra, Materia seca, Proteína cruda, Uso medicinal

Citation: ROMÁN-MIRANDA, María Leonor, MORA-SANTACRUZ, Antonio, AVENDAÑO-LÓPEZ, Adriana Natividad and SÁNCHEZ-MARTÍNEZ, José. Chemical composition of *Tithonia diversifolia* (Hemsl.) A. Gray (Asteraceae) and diversity of uses in rural areas. ECORFAN Journal-Ecuador. 2020. 7-12:23-33.

*Correspondence to Autor (Email: adriana.avendano@academicos.udg.mx)
† Researcher contributing as first author.

Introduction

Tropical livestock based their diet on pastures; these have an extraordinary capacity to produce biomass (Palma, 2005), however, the marked seasonality that exists in most of the country, causes a strong forage deficit in the dry season, especially for extensive livestock farming, which during eight months of drought, consumes the foliage and fruits of forage trees and shrubs, present in the pastures, a valuable resource, as it is the only source of fresh and good quality food during the dry season. Among the species mostly used for animal feeding, legumes stand out, predominating among them, different types of *Acacia* sp., *Leucaena* spp., *Gliricidia sepium*, *Calliandra* spp. and *Caesalpinia* spp., which are characterized by their high protein content, up to 30% in foliage and up to 24% in fruits (Román *et al*., 2004; Palma, 2005; Román *et al*., 2013; Palma *et al*., 2019). On the other hand, in most tropical countries there is a great diversity of plant species, which can contribute to animal feeding (Valenciaga *et al*., 2018; Herrera *et al*., 2020) and reduce production costs in the livestock activity, including *Tithonia diversifolia*, a shrubby plant of the family (Asteraceae), which grows both in tropical and temperate climates.

The types of habitat where it is distributed include: oak forests, tropical evergreen forests, deciduous forests, secondary vegetation, along the roads, as well as in cultivated fields, its altitudinal range goes from sea level to 2500 m. Likewise, in the review of the material of herbarium specimens, collected in the state of Jalisco, they report it in areas near Puerto Vallarta, collected in a tropical deciduous forest and secondary vegetation, associated with *Ficus*, *Enterolobium*, *Hura*, *Gliricidia*, *Hyptis*, *Solanum*, *Tridax* and *Cosmos* among other species.

Studies carried out in Colombia demonstrate the forage potential of this species and its nutritional quality, which without being legume, has high levels of crude protein that range from 14.84 to 28.75%, due to its nutritional value and diversity in its chemical composition (Ríos and Salazar, 1995; Ríos, 1999; Mahecha and Rosales 2005; Mahecha *et al*., 2007; Gallego-Castro *et al*., 2017; Rivera *et al*., 2018), as well as other research carried out in Cuba by (Galindo *et al*., 2018, Valenciaga *et al*., 2018) make this species a viable option to be used in agricultural production systems.

Galindo *et al*. (2018), reported that its use in the animal diet reduces the production of methanogens and protozoa and has beneficial effects on the microbial ecology of the rumen. Lescano-Más *et al*. (2016) stated that in young cattle it contributes to reducing the parasite. Furthermore, this species presents desirable characteristics that make it attractive to be incorporated into silvopastoral systems; including having a large root volume, and a special ability to recover the scarce nutrients present in the soil (Pérez *et al*., 2009), has a wide range of adaptation and distribution in tropical and temperate zones, a characteristic that in some parts of the world, consider it as an invasive species in different ecosystems, mainly in Africa and China (Sun *et al*., 2007; Muoghalu, 2008; Ajao and Moteetee, 2017), it tolerates conditions of acidity and low fertility, it is resistant to poor soils and it can withstand pruning at ground level, it is tolerant to burning and has a rapid growth, it is not demanding of inputs or handling for its cultivation (Mahecha and Rosales, 2005; Pérez *et al*., 2009).

In Colombia they evaluated the production of dry matter with plants obtained through asexual and sexual means; planting 36 plants per plot of (20 m^2), with a density of 1.8 m^2, with weed control and fertilization, obtaining productions of 13, 17 and 19 t / DM / ha, by establishing the cultivation by stakes, plants produced by seed sexual in in vitro conditions and plants obtained by sexual seed, managed in seedlings (Gallego-Castro *et al*., 2015).

ISSN-On line: 1390-9959

Herrera *et al*. (2020), studied the distribution of this species in relation to climate change and its chemical composition, considering precipitation, temperature and distribution, highlighting that the correlation between climatic factors and chemical composition was variable, with the highest coefficients (r) for phosphorus, with maximum temperature (0.64) and average temperature (0.63), OM and ashes with minimum temperature (0.62 and -0.62), respectively; cellulose with the maximum temperature, total rainfall and the number of days with rain, with values of: (-0.62, -0.69 and -0.73), respectively, and nitrogen (N) with rainfall and its distribution (- 0.81 and -0.82, respectively). Being for the other components, low and not significant correlations; reaching the conclusion that climate factors act individually and / or interrelated, which is relevant to know, for the management of the plant in climate change scenarios.

Tithonia diversifolia is a species native to Mexico and Central America. However, in our country, it has not been used intensively as a forage species in livestock production systems, nor in the diversity of uses it presents, so the objective of this study is:

Objective

Evaluate the nutritional quality of *Tithonia diversifolia* from three different locations, as well as rescue the experiences of other countries on its multiple uses, to enter silvopastoral systems.

Materials and methods

The study began with a bibliographic review, as well as a consultation in the herbarium of the Institute of Botany, of the University of Guadalajara, to know its distribution based on reviewed specimens. The plant was collected in three different locations: one in the municipality of Cuauhtémoc, in the state of Colima, present in weed vegetation, another in El Tuito, municipality of Cabo Corrientes, used as an ornamental and the other collected in the Botanical Garden of the University Center of Biological and Agricultural Sciences. The climates present are:

Warm subhumid with rains in summer Aw1, with rainfall of 1200 mm and mean annual temperature of 24 °C for Cuauhtémoc, and semi-warm subhumid with rains in summer for the site of El Tuito A (C) w1, with 1100 mm of rainfall per year and average annual temperatures between 22 and 26 °C., the same climate as Las Agujas in the municipality of Zapopan, Jalisco, although with lower temperature ranges from 20 to 24 °C. Later, made revisions in the herbaria of the Universidad Nacional Autónoma de México (MEXU) and the Instituto Politécnico Nacional (IPN), to know its geographical distribution, altitude ranges, types of vegetation where it occurs and the uses attributed to it in rural areas.

From the last two sites, a previous evaluation of vegetative propagation was carried out with stakes of lengths between ranges for T_1 (20 to 25 cm), T_2 (26 to 32 cm), and T_3 (33 to 40 cm), With variable diameters between the different lengths. Subsequently, they were subjected to water stress to measure survival.

The edible material was collected in the three aforementioned sites and consisted of leaves and petioles, 500 g of fresh material, which were transported in a cooler, so that the bromatological analyzes could be carried out in the bromatology laboratory to determine dry matter (DM) and crude protein (CP), which are the most relevant parameters in forage species, in addition to forage production and acceptability in consumption by the animal species, using the technique proposed by the Association of Official Analytical Chemists (AOAC, 1990). Likewise, fiber fractions were analyzed: neutral detergent fiber (NDF), Acid detergent fiber (ADF), cellulose, hemicellulose and lignin, by the method of (Van Soest and Wine, 1967).

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Results and Discussion

Vegetative propagation

In the evaluation of vegetative propagation, it was observed that the best values of the variables evaluated were those from El Tuito. Likewise, the highest number of species with regrowths were for treatments 1 and 2 (Table 1), which after submitting them to a 4-month drought period, were the only treatments, which of 10 plants evaluated at least 4 of they managed to survive, not the T_3 ones (lengths of 33 to 40 cm), of which none of them survived, probably due to a greater demand for water. In this regard, in other studies, it is highlighted that this species can be propagated sexually (by seed) or by cuttings; recommending vegetative reproduction (Pérez *et al*., 2009). These authors and (Hartmann and Kester 1995, cited by Pérez *et al*., 2009) indicated that propagation by cuttings produces a more efficient rooting; if the cutting and planting conditions are optimal, thus allowing greater survival and favoring their ability to produce biomass. Ríos and Salazar (1995) achieved productions of 82, 57 and 42 tons per ha, at densities of 2600, 1800 and 760 plants / ha, with 110 days after sowing and with irrigation application. Also, Mauricio *et al*. (2017) highlighted reproduction by cuttings, recommending a length of 20 to 40 cm, buried vertically and at a shallow depth, the minimum and maximum length of the treatments suggested in this study.

Treatment	Diam. (mm)	Sprouts	L (cm)	Survival
AT_1	17.77	3.42	11.62	4
BT_1	19.57	4.83	10.64	9
AT_2	17.85	2.63	12.13	5
BT_2	18.82	4.14	9.76	6
AT_3	20.32	4.00	20.38	0
BT_3	19.28	3.83	8.77	0
T1 (Length: 20-26 cm); T2 (Length: 26 to 32 cm); T3 (Length: 33 to 40 cm)				

Table 1 Behavior of the shoots of the *Tithonia diversifolia* cuttings, from Las Agujas (A) and El Tuito (B), Jalisco.

It is a forage plant, with high levels of protein and high digestibility, contributing in an important way to animal nutrition, both for ruminants and monogastrics, it is also used in the supplementation of poultry feed, to take advantage of its carotene content and give color to egg yolk and chicken meat (Ríos, 1999). Therefore, this study presents its chemical composition that makes it attractive in animal production.

Chemical composition

Regarding its nutritional quality, it can be observed that it presents high levels of protein (18.42 to 31.54%), compared to legume species, which are characterized by their high protein content: *Tithonia diversifolia* has higher values than many tree species of this family and the results obtained in this study, for the materials from Cuauhtémoc, Colima and El Tuito are higher than those reported by other authors among them (Rosales, 1996; Navarro and Rodríguez, 1990 and Olivares, 1999), the latter, who in turn found high levels of calcium (2.3%) in this species, despite growing in acid soils. *Tithonia diversifolia*, presents high dry matter contents of 98.44%, except the material from Las Agujas, Zapopan that presents 21.96%.

The contents of the evaluated parameters are also higher than that reported by Gallego-Castro *et al*., (2017), for dry matter, who report values of 12.45 to 12.90% and of crude protein, values of 12.76 to 14.10%. It must be considered that these differences are probably due to soil conditions, environmental characteristics and part of the analyzed plant, since in this study the edible material consisted of leaves and petioles, in contrast to the aforementioned authors, who analyzed leaves and tender stems. Regarding the ash content, the values were similar in both studies (15.50 to 16.19%), with the exception of the material obtained in the municipality of Cuauhtémoc, Colima with a value of 18%. Ponce, (2019), reported DM contents of 90% and CP of 16.09% after 30 days of regrowth. The nutritional quality of arboreal or shrub species such as *Tithonia*, accumulate as much nitrogen as legumes, in addition to presenting high phosphorus contents.

For their part, Pérez *et al*. (2009), indicated that the nutritional quality depends on the phenological stage of the plant; which generally ranges from 14.8 to 28.5% after flowering and advanced growth; dry matter content 14.1 to 23.2% in advanced growth and after flowering and nitrogen-free extract from 1.91 to 2.4% for advanced growth and after flowering, respectively (Navarro and Rodríguez, 1990), lower values in all parameters, compared with those that occurred in each of the sites of the present study.

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Also the values reported by Téllez and Mendoza (2014), indicated crude protein contents of 19.5%, however, it should be noted that these authors evaluated the entire plant and although they do not indicate its phenological stage, the value was slightly higher in plants from Las Agujas, Zapopan, but inferior to those mentioned in Cuauhtémoc and El Tuito. Medina *et al*. (2009), who carried out a study in Trujillo, Venezuela evaluated morphostructural variables and biomass quality, in plants in the initial growth stage with protein contents of 21.3 to 23.7%; Values similar to this study for the Cuauhtémoc and Zapopan sites, but lower than those reported for plants from El Tuito (Table 2).

Regarding the content of fiber fractions, there were low values (30.81, 33.30 and 34.08%), with respect to (NDF), and (22.48, 25.74 and 31.69%), for (ADF), which indicates that it presents high digestibility of dry matter; that suggests a better animal behavior in its consumption (Table 2); These values are lower than those reported in Colombia in the Upper Tropics for NDF from 50.21 to 53.81 and ADF from 48.18 to 48.87% (Gallego-Castro, *et al*., 2017). On the other hand, Ponce (2019) indicated content of neutral detergent fiber (NDF) of 67.24% and acid detergent fiber (ADF) of 45.84%, high values where the digestibility of the dry matter would be from low to regular, limiting consumption from the animal. Téllez and Mendoza, (2014), reported NDF contents of 58.8% and for ADF of 42.2% with an *in vitro* digestibility of dry matter (DIVMS) of 57.6%. For their part, Medina *et al*. (2009), indicated similar values, to those presented in this study, for fiber fractions: with contents of 33.27% for (NDF) and 27.37% for (ADF) and a high DIVMS of 68.9 to 73.4%.

Determination	Cuauhtémoc, Colima	El Tuito, Jalisco	Zapopan, Jalisco
Dry matter	98.44	98.92	21.96
Crude protein	21.64	31.54	18.42
Ethereal Extract	3.12	2.73	2.60
Ashes	18.00	15.70	17.69
Fiber	27.07	26.30	10.31
NFE	28.61	22.65	50.98
NDF	30.81	34.08	33.30
ADF	22.48	25.74	31.69
Lignin	16.23	19.39	23.67
Cellulose	6.25	6.35	8.02
Hemicellulose	8.33	8.34	1.61
NFE= nitrogen-free extract			

Table 2 Chemical composition of leaves and petioles of *Tithonia diversifolia*, based on dry matter in (%)

Diversity of uses

Tithonia diversifolia has multiple uses in most countries of origin and where it has been introduced, including its use as green manure, due to its rapid growth, high capacity to fix nitrogen and accumulation of phosphorus, with beneficial effects on poor soils (Scrase *et al*., 2019). In Kenya it is used as a source of nitrogen, phosphorus and potassium in maize and rice crops (Jama *et al*., 2000), also for the control of termites (Adoyo *et al*., 1997).

Another alternative for use is as an insecticide since its insecticidal properties have been demonstrated to combat the leaf defoliator ant (Pantoja-Pulido *et al*., 2017). Due to the beauty of its yellow or orange flowers and its prolonged flowering, it is cultivated in several countries in Central America, South America, Asia and Africa, for ornamental purposes. Within the bibliographic review, we can cite very varied uses (Table 3), from ornamental, medicinal, forage and also due to its high content of pollen and nectar for the production of honey, contributing in an important way to the beekeeping industry. It is a soil improver due to its high nutrient content (nitrogen, phosphorus and potassium) and its rapid decomposition, which makes it available for other crops, improving the recycling of nutrients from these elements.

Use	Description	Country	Date
Control of gastrointestinal stronglypids	It was made in young cattle, during the rainy and un rainy season	Cuba	Lescano-Más, *et*al., 2016
Beekeeping profit	Producer of nectar and pollen	Mexico, Colombia Philippines	Roman *et*al., 2006; Rios, 1999; Cairns, 1997, cit. Rivers,1999
Forage	Feeding goats in cutting and hauling systems Ramoneo of sheep, feeding tilapias and incorporates into rations to feed hens.	Philippines Colombia Cuba	Cairns, 1997, cit. Rios, 1999 Galindo *et*al., 2017

ISSN-On line: 1390-9959

	Consumption of Holstein cows It feeds rabbits and pigs		
Attraction of beneficial insects	Attraction of pollinators and beneficial insects	Colombia	Rios, 1999
He is credited with Insecticide Activity	It is used by farmers for pest control	Africa	Pantoja-Pulido *et*al., 2017
Medicinal	In the treatment of eczema and skin lashing in pets. To decrease abortions and cannibalism in conejas	Guatemala Colombia Venezuela	Nash, 1976, cit. Rivers. 1999 Mahecha and Rosales, 2005
Living and windbreaker fences	Protection and conservation of water sources. Like a windbreaker curtain around the apiaries	Colombia	Rios, 1999
Green fertilizer and soil improver	Incorporation of biomass for its rapid decomposition on in rice and maize crops. In bean crops with a screening system, *T. diversifolia was found to*have high levels of N, P and K Used to recover grass-invaded soils	Kenya Costa Rica Philippines	Jama, 2000, Thor *et*al., 2002 George, *et*al., 2001 Rios, 1999

Table 3 Different uses of *Tithonia diversifolia*, reported in the literature

In many countries its main use is as forage and medicinal, for various ailments, so its two main uses are described in more detail:

Forage use

Tithonia diversifolia has been used as animal feed in several countries such as Cuba and Colombia, mainly in CIPAV and in the University of Sao Joao del Rei-Brazil (UFSJ), highlighting its nutritional quality that varies depending on the phenolic stage of the plant, its Forage production based on dry matter of 5.6 to 8.1 t / ha / year and on fresh basis was obtained from 24.7 to 41.3 t / ha / year (Mauricio *et al*. 2017). It is a species with good biomass production capacity and rapid recovery after cutting, which depends on the sowing density, soil characteristics and the vegetative state. Due to its high protein value, it is used in both ruminants and monogastrics; This species is used for cutting and hauling: for sheep, cattle, pigs, rabbits and buffalo; as well as in grazing together with grasses in the herbaceous stratum, in the food diet, it is generally used pre-dried or ground in the form of flour and feed (Pérez, *et al*., 2009).

In Colombia it is part of the intensive silvopastoral systems (SSPi), many of which have been carried out by CIPAV, together with forage grasses and some other tree species, including *Leucaena leucocephala* and *Guazuna ulmifolia*.

Mahecha *et al*., (2007), pointed out the advantages in the use of *Tithonia diversifolia* foliage as a forage supplement for dairy cows, with no significant difference between the use of concentrates and different inclusions of the foliage of this species of up to 35%. In forage banks with a density of 12,500 plants / ha, productions of 107.6 t / ha / per year of green forage and 24.6 t / ha / year of DM were obtained (Tellez and Mendoza, 2014).

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Medicinal use

Tithonia diversifolia is valued by many cultures, for its medicinal properties. It is a species used in traditional medicine, due to its multiple properties, due to the presence of secondary metabolites such as antimicrobial and anti-inflammatory (Sousa *et al*., 2019) to combat malaria (Afolayan *et al*., 2016), indicating that the extracted extracts with dichloromethane and methanol 1: 1 of *Tithonia diversifolia* and *Lawsonia inermis* were more effective against the *Plasmodium* parasite parasite than the aqueous extracts, used in traditional medicine; *T. diversifolia* has also been highlighted for its use against diabetes (Sari *et al*., 2018) and cancer (DiGiacomo *et al*., 2015).

Antioxidant properties are attributed to it; González-Sierra *et al*. (2019), indicated that the roots have a higher antioxidant capacity with 1.10 mg; followed by the leaves with 1.08 mg and finally the stems with 0.50 mg of ascorbic acid / mg of extract. They also reported phenol, flavonoid, coumarin, quinone and terpenoid content. It is important to point out that the concentration of these metabolites varies according to the phenological stage of the plant, the time of year, the characteristics of the soil, the region where the sample is obtained and environmental conditions of the area; noting that both the nutrient content in the soil, mainly Ca and P, as well as climatic conditions, seems to affect the presence of volatile constituents, mainly the content of sesquiterpenes in the leaf (Sampaio and Da Costa, 2018). *T. diversifolia* has shown variability in the content of secondary metabolites (Rivera *et al*., 2018), hence the difference in the results and the versatility of the plant, to adapt to different environments.

The oxidant activity can be associated with the content of phenols and flavonoids, which is explained by the redox properties of phenolic compounds (Gutiérrez-Sierra *et al*., 2019). The antioxidant activity, in general, is given by its ability to sequester free radicals, iron chelator, as well as the inhibition of oxidase enzymes. These metabolites are capable of avoiding or attenuating oxidative stress, due to reactive oxygen species (ROS), which prevents the oxidation of important biomolecules (proteins, nucleic acids, lipids and sugars).

This is associated with the appearance of diseases such as: cancer, Alzheimer's, aging, cataracts, diabetes, hypertension, cardiovascular diseases, among others (Valco *et al*., 2007; Sies, 2010; Dzialo *et al*., 2016). The extracts of the roots and leaves of *T. diversifolia* presented the highest concentrations of phenols and flavonoids (González-Sierra *et al*., 2019), (Table 4).

Disease Type	Part of the plant used	Countries	Bibliographic reference
Diabetes, malaria, snake bite, gastric ulcer, rubella and wounds	Leaves and roots	Costa Rica, Republic of the Congo, Kenya, Nigeria, Uganda, Mexico and Venezuela	Ajao and Moteetee, 2017 Afolayan et al., 2016
Bruises, abscesses	Stems and leaves	Venezuela	Frei, *et al*., 1998
Viper bite	Leaves as an antidote	Kenya	Owuor *et al*., 2005
Liver problems	The leaves in cooking	Colombia	Ríos, 1999
Malaria remedy		Guatemala	Nash, 1976, cit. Ríos, 1999
Hits	Macerated leaves like árnica	Cuba	Ríos, 1999
Spasms and cold	Cooking leaves	Colombia	Ríos, 1999
Malaria		Mexico and Nigeria	Heinrich, 2000; Ajaiyeoba *et al*., 2006
Dermatological problems, wounds	Toasted leaves	India	Heinrich, 2000; Frei, *et al*., 1998

Table 4 Use in traditional medicine of *Tithonia diversifolia* and parts used

The information collected in the herbarium specimens indicates a wide geographical distribution, as well as different habitats, where it occurs, including home gardens and coffee plantations, the altitudinal ranges include from those close to sea level to altitudes of 2000 m, generally in cloud forest and the main uses are as ornamental and medicinal, only in two states its use as forage is reported (Table 5).

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State	Common name	Habitat	Altitude	Use
Campeche	sunkak margarita	Acahual Smsp	20, 80	Ornamental
Chihuahua		Oak forest	1400	Ornamental
Colima	tacote, arctic	Ruderal	400, 500, 1100	Ornamental
Warrior	Margarita		1900	Ornamental
Jalisco	daisy, tacote, garnic, sunflower	HC, Sbc, Pine Forest, Smsp, Smsc and BMM	50,400, 1500, 1900	Ornamental
Oaxaca	Arnica	Oak Forest, Ruderal	2000	Medicinal
Tabasco	arctic, bitter, lion's hand and carolina	HC and Smsc	25	CV and Medicinal
Veracruz	aggregate, gigantic, bitter, maroon, maroon sunflower and tamchich	Sasp, Sbc, Pine Forest, Acahual, Cafetales, Oak Forest, Ruderal and BMM	110, 120, 152, 530, 1250, 1300, 1750, 2190	Medicinal in wounds, swelling, to cure rashes. The leaf and sap, Ornamental and Forage are used
Yucatan	Amargosa	Smsc and Smsp	10, 20	Ornamental, Medicinal and Fodder

Table 5 Types of habitat, altitude and uses in rural areas of Tihonia diversifolia

Conclusion

The results indicate that due to its high nutritional quality, its wide distribution and its diversity of uses, *T. diversifolia* is a viable option to be used in semi-intensive animal production systems, both in tropical and temperate zones.

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