An overview of Cholla (*Cylindropuntia spp.*) from Sonora, Mexico

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ABSTRACT

The cholla (*Cylindropuntia cholla*, *C. imbricata*, *C. fulgida,* or *C. bigelovii*) is a cactus that grows in desert regions such as Sonora, Mexico. It is capable of surviving extreme conditions, with low water availability including extreme temperature fluctuations, high ultraviolet radiation, low nutrient content soils, and drought. This Cactaceae plant is arborescent or shrub, with a well-defined trunk, a main stem with verticilos of lateral branches, and strongly tuberculate; the stem has tubers arranged in series of spirals and this tubers have areoles. A short-term use of this Cactaceae is obtaining its root for folk medicine and stalks as new foodstuffs like cholla juice. In the long term, cholla juice provides a precedent in establishing processes for the development of products such as cholla tea, cooked slices, and pickled, dehydrated product, among others. The cholla plant shares characteristics with other members of the plant family Cactaceae and its chemical composition (fiber, carbohydrates, etc.) is also similar to nopal cactus. Therefore, it has the potential of medicinal properties that would counteract symptoms of chronic-degenerative diseases such as diabetes. Moreover, identification and characterization of its chemical compounds, toxicity, processing effect on bioavailability, mechanisms of action, and health effects of bioactive compounds, have been scarcely investigated and therefore, requires scientific evidence on these important aspects.

Keywords: Cholla, *Cylindropuntia* spp, cactus, distribution, chemical composition.

RESUMEN

La cholla (*Cylindropuntia cholla*, *C. imbricata*, *C. fulgida* o *C. bigelovii*) es un cactus que crece en regiones desérticas como Sonora, México. Se caracteriza por sobrevivir a condiciones extremas, tales como: baja disponibilidad de agua, incluidas fluctuaciones de temperatura extremas, alta radiación ultravioleta, suelos con bajo contenido de nutrientes y sequía. Esta planta de Cactaceae es arborescente o arbustiva, con tronco bien definido, tallo con verticilos de ramas laterales, fuertemente tuberculado; con tubérculos dispuestos en series de espirales, a veces los tubérculos forman costillas y estos tubérculos tienen areolas. La aplicación de esta Cactaceae a corto plazo está en la obtención de un producto de la raíz para el mercado de la medicina tradicional y la exploración del uso de tallos de cholla para obtener nuevos alimentos como el jugo de cholla. A largo plazo, la experiencia de obtener el jugo de cholla establece procesos para obtener productos tales como el té de cholla, trozos cocidos, encurtidos, productos deshidratados, entre otros. La planta de cholla comparte características con otros miembros de la familia de plantas Cactaceae y su composición química (fibra, carbohidratos, etc.) también es similar al nopal, por lo que tendría el potencial de propiedades medicinales que contrarrestarían los síntomas de enfermedades crónico-degenerativas, como la diabetes. Además, la identificación y caracterización de los compuestos químicos, su toxicidad, el efecto del procesamiento sobre su biodisponibilidad, los mecanismos de acción y los efectos en la salud de los compuestos bioactivos de la cholla, son aspectos que apenas se investigan y requieren documentación de la evidencia científica sobre estos aspectos importantes.

Palabras clave: Cholla, *Cylindropuntia* spp, cactus, distribución, composición química.

INTRODUCTION

The Cactaceae, as well as the Asparagaceae family, were a source of American Indian food, drink, medicine, and raw material for their homes, clothing, tools, and manufacture of hunting and fishing weapons, which made these plants indispensable for their development. Among the succulent plants, Cactaceae is the most representative family of the semi-arid and arid zones of Mexico and the United States, as well as other places in South America. There are native Cacti in North and South America and the West Indies (Gibson and Nobel, 1986). Within these areas, Mexico has the major quantity of species of Cacti (Paredes-Aguilar *et al.*, 2000).

The Cactaceae plants are also found in tropical, subtropical, and template zones (Guillot-Ortíz *et al.*, 2008). Cacti are known around the world as unusual looking plants that grow in hot, dry, and hostile desert areas, with about 125 genera and more than 2,000 species. Sixteen genera are found in North America (Elpel's, 2018).

Cacti appear in various habitats, from harsh hot deserts to tropical rainforests, as well as cold areas with freezing temperatures. Most cacti grow in arid and semiarid zones with high summer temperatures. They are the species with the highest temperature tolerance, enduring 50 to 55°C when properly acclimated. Unfortunately, many species of cacti with agricultural potential are damaged by freezing temperatures, like the epiphytic cacti, in the genera *Hylocereus* and *Selenicereus,* which are native to tropical forests. Cacti show great adaptability to various soil conditions as they can grow in poor, infertile desert soil and have a wide range of soil pH tolerance (Nobel, 1988).

Their remarkable adaptability along with their unique shapes, sizes, and appearances have spread cacti around the world (Nobel, 1988, Shackleton *et al.,* 2017). Nevertheless, cacti face a complex problem, which is risking their survival. They are affected by non-rational utilization due to the lack of regulation by governmental agencies. This non-regulated use goes from ethnic medicine and food to magical and religious rituals (Thornber, 1911; Vinson, 1911; Getmansky, 1973; Felger and Moser, 1991; Anderson *et al*., 2001; Feugang *et al*., 2006). Other threats to *Cactaceaes* include the loss of their habitat due to deforestation because of agricultural and livestock development, overgrazing, exchange of natural vegetation by exotic species for forage production, use of pesticides, among others (Aguilar *et al*., 2000).

American botanists Nathaniel Britton and Joseph Rose published in multiple volumes, between 1919 and 1923, a landmark study that extensively reorganized cactus taxonomy and it is still considered as a cornerstone in the field. The dicotyledonous family Cactaceae has three subfamilies: *Pareskioideae*, *Opuntioideae, and Cereoideae* (Britton and Rosi, 1919, Bravo-Hollis, 1978). *Pereskioideae* is the smallest of the three subfamilies, containing about 20 species and characterized by prominent leaves. The stems, branches, and leaves are somewhat succulent. With areolas, supported with a leaf tectriz, they carry spines; simple flowers or inflorescences, seeds with a thin, fragile and black test (Bravo-Hollis, 1978).

The Opuntioidae subfamily comprises arborescent cacti, shrubs, and even creepers. Stems are cylindrical, almost globose to claviform, or somehow branched cladodes. Leaves have a small cylindrical limb, as prominent tubers. Circular areolas have glochids and thorns. Dry or fleshy fruit are sometimes prolific. Seeds have the color of linen or black and disc-shaped with very hard arils (Bravo-Hollis, 1978). The Opuntioidae subfamily is distinguished from other cacti by four characteristics. First, the stems grow in distinctly jointed segments. The elongation of joints is permanently terminated by the onset of the dry season; subsequent plant growth occurs by the initiation of new joints by branching from the areoles, whereas other cacti have indeterminate growth. Second, whether or not they have regular spines, opuntioid areoles bear glochids, small to minuscule barbed spines that are very sharp and brittle, and very easily detached. Third, rudimentary leaves are present on new joints. Finally, the seeds have a pale covering called an aril and most other cacti have shiny black seeds (Arizona-Sonora Desert Museum, 2018).

The genus *Cylindropuntia* belongs to the subfamily Opuntioideae and comprises 33 naturally hybridized species. *Cylindropuntia*, with 12 present-day taxa, is the most diverse cactus genus in the flora area as well as in the Sonoran Desert (Felger *et al*., 2014).

GENERAL ASPECTS OF THE *CYLINDROPUNTIA* GENUS

Collectively known as "chollas", the *Cylindropuntia* cacti are distinctive and represent an important component of the United States and Mexico deserts. Although George Engelmann originally described *Cylindropuntia* in 1856 as a subgenus of *Opuntia*, in 1935 it was removed and raised to the genus of the *Cactaceae* family by Frederic Knuth (Anderson *et al*., 2001).

The genus *Opuntia* is polyphyletic, whereas the DNA sequencing studies show that *Cylindropuntia* is a distinct, monophyletic line, clearly separated from any of the opuntioids of

South America (Wallace and Dickie, 2002). The complete name of the genus is "*Cylindropuntia* (Engelm.) F.M. Knuth 1935", but the abbreviated form *Cylindropuntia* will be used in this review. *Cylindropuntia* is better understood because of the research of Pinkava (1999) and colleagues (1971, 1973, 1979, 1982, and 1985), working primarily at the Arizona State University. Subsequently, systematic research by Rebman (1995) on the cholla cacti of Baja California helped elucidate the relationships of this taxonomically difficult cactus group. Natural hybridization is common in *Cylindropuntia*, a characteristic well documented by Pinkava and McLeod (1971), Pinkava *et al*. (1973), Pinkava and McGill (1979), Pinkava and Parfitt (1982), and Pinkava *et al*. (1985), who have extensively studied the cytology of the opuntioids and determined that many populations already named are hybrids.

There are 32 species of *Cylindropuntia* already recognized, which are distributed through South West and central United States of America (USA), Mexico, West Indies and introduced and widely cultivated in South America (Chile, Ecuador, and Peru) and South Africa (Guillot-Ortíz and van der Meer, 2006). The most distinctive feature of *Cylindropuntia* is the presence of papery sheaths on the spines, which eventually fall away; the seeds are also distinctive. *Cylindropuntia* is shrubby or treelike, erect, with many branches and indefinite growth. Stem segments are cylindrical to somewhat club-shaped, straight, glabrous, firm to easily detached, of varying lengths, distinctly tuberculate. Areoles are variable in shape and glochids are present. Spines are entirely covered with papery, deciduous, epidermal sheaths, which fall away. The main spines are basally flattened or not at all.

In the Sonoran Desert, some chollas (*Cylindropuntia*) have diurnal flowers, except for crepuscular or nocturnal *C. fulgida* and *C. leptocaulis*, however, these flowers are sterile. Most cacti have succulent fruits adapted to animal dispersal and relatively few have fruits that dry at maturity. The tendency of dry fruits is more prominent in the xeric, western reaches of the flora area rather than in the less arid eastern parts of the flora area. Seven species or 22% of the cactus of this area have fruits that generally become dry at maturity or shortly thereafter (Felger *et al.,* 2014).

Cacti were important food supplements throughout the southwestern United States in both prehistoric and historical times. Among the most important is the cholla (*Cylindropuntia*), from which the buds were mainly consumed during April or May. The young cladodes (joints or stem segments) of larger chollas were harvested in spring and cooked as vegetable. The fruits of fleshy or succulent-fruited species were eaten fresh or cooked, and the large "seeds" were discarded. The spines and glochids of chollas and prickly-pears were removed by several methods including vigorously brushing them in sand or gravel (Gasser, 1981, Felger *et al.,* 2014). Regarding medicinal use, in Sonora, the fruit's juice, skin, and pulp, as well as the plant's roots were used to treat diarrhea and general pain, including those of teeth and kidney stones, as well as for fever (López & Hinojosa, 1988).

Cylindropuntia bigelovii (Engelmann) F.M. Knuth 1935

Cylindropuntia bigelovii is also known as “teddy bear cholla”, “cholla guera”, “golden-spined jumping cholla”, or “velas de coyote” (Turner *et al*., 1995). It is an erect, tree-like or shrubby species of up to about of 1-1.5 m high. It has green joints, which are cylindrical, with a length of 15 cm and a diameter of 5 cm. It has prominent elongated tubercles. Its areoles are dense and white, with yellow glochids and many straw-colored spines, with six to ten radials up to 2.54 cm long, as well as six to ten slightly longer centrals. Chollas often are 0.5-1.8 m tall, with a trunk erect, stout, straight, and beset with dead, persistent branches (joints) with blackened spines.

As with many chollas, the root system is a cluster of fibrous roots with a few horizontal lateral roots of indeterminate lengths. Joints relatively short and thick, and readily detaching, green all year, with extrafloral nectaries (areolar glands) green when fresh, seen on the new growth.

Spines dull yellow and densely covering and obscuring the stems segments (joints), and with prominent yellowish spine sheaths. Flowers yellow-green, 3.5–5.5 cm wide, attached more firmly than the ultimate joints. Inner tepals 8-10, widely separated and not completely ringing the receptacle and not hiding the short outer tepals; inner tepals 2.5-3 x 1 cm, pale yellow-green, the margins essentially colorless and erose. Filaments have bright green; anthers bright yellow, often stunted and lacking pollen.

Flowering is between March to April. Fruits mostly 3-3.5 x 2-2.5 cm, yellow, solitary, leathery and moderately fleshy, strongly tuberculate, spineless or with slender bristle-like deciduous spines 9-15 mm long, becoming spineless or essentially so at maturity; fruits might persist for many months under favorable conditions, or soon falling away during dry conditions. Seeds variously present or absent (Felger *et al*., 2014).

The geographic range in which *C. bigelovii* is found includes Sonora, Arizona, California, Nevada, Baja California, and Baja California Sur (Wilder *et al*., 2008). Two varieties of *C. bigelovii* are recognized. *Bigelovii* variety is present in California, Nevada, Arizona, New Mexico, and Baja California. *Ciribe* variety is found only in Baja California Sur and it tends to produce long chains of fruits (Turner *et al*., 1995).

Cylindropuntia cholla (Weber) F.M. Knuth 1935

Cylindropuntia cholla is an arborescent plant of 1 to 5 m of height, with wide and rounded tubercles of up to 1 cm of width in the base and of 1.5 to 3 cm in length, and presenting orbicular to elliptical loops of 3 mm diameter. They present 5 to 13 thorns, which are yellowish when young and subsequently turn to dark gray. Their flowers are 2.5 to 3 cm of diameter with peach to purple colors. It has fleshy but sparse greenish juice (Bravo-Hollis, 1978). Flowers appear from April to May (spring season) and are 2.5 to 3 cm across with colors from peach-pink to pale purplish. The fruits are fleshy but not juicy, with a length of 3 to 5 cm, a diameter of 2-3 cm, and spineless when they mature (Turner *et al*., 1995).

Cylindropuntia cholla is one of the two *Cactaceae* that have been found in a high-richness endemic region of Baja California, toward the north of the Magdalena Plains (Riemann and Ezcurra, 2007). It has also been observed in Sierra La Asamblea, Baja California Peninsula, above 800 m over sea level (Bullock *et al*., 2008). It is distributed through South Arizona and Sonora, especially the west part of the state and is common on desert flats near Bahia Kino (Wilder *et al*., 2008). It is most abundant on mesas, plains, and valley bottoms (Turner *et al*., 1995). *C. cholla* is closely related to *C. fulgida*, with subtle differences in flower, color, fruit shape, and size (Turner *et al*., 1995; Wilder *et al*., 2008).

***Cylindropuntia fulgida* (Engelmann) F.M. Knuth 1935**

Also known as boxing-glove cactus, boxing-glove cholla, “brincadora”, chain-fruit cholla, club cactus, jumping cholla, smooth chain-fruit cholla, and Sonoran jumping cholla, *C. fulgida* is a tree-like plant with abundant branched, spreading crowns, and 1-3 m tall with widely spreading, branching trunks (Turner *et al*., 1995). The stem segments are spiny, and the spines are gray-green but become blackish obscuring the joints.

Terminal segments are easily dislodged, have a length between 6-23 cm and a diameter of 2.0-3.5 cm with broadly oval tubercles. They have triangular areoles with yellow to tan wool colored, becoming gray to black with age. Glochids are yellow and 1-3 mm long. Spines are on most areoles or nearly absent, in a range of 0-18, yellow colored but darker as they age. They can be erected to spread and bent downward, with a length up to 3.5 cm, and sheaths whitish to yellowish and baggy of tight-fitting (Photo 1).

Pink to magenta flowers open in the late afternoon (Photo 2). Its fruits are green or with slightly yellow color, widely ovoid and 2.0-5.5 cm long with a diameter of 1.3-4.5 cm. They are mostly spineless, proliferating into long pendulous chains. Frew seeds, apparently many fruits are seedless (Bravo-Hollis, 1978).

Two varieties of *C. fulgida* are often recognized. *Fulgida* variety is 3.5 cm long and has interlaced spines presenting baggy sheaths. *Mamillata* variety has only slightly interlacing spines of 2 cm long with tight-fitting sheaths (Photo 1). They are found in the Sonoran Desert of Arizona and Sonora, Sinaloa, and Baja California, Mexico (Anderson *et al*., 2001).

The fleshy fruits are available all year and were often a significant food resource for local people. The fruits were consumed fresh or cooked and could be dried and stored. Dried, black gum that accumulates on the stem from injuries is edible and has been much appreciated by Seris and Yaquis. This dried gum is ground, cleaned, and cooked, often in animal fat, or eaten uncooked with water added. The stems, gum, fruits, and roots also have been used medicinally (Felger *et al*., 2014).

Photo 1. Cholla cactus (*Cylindropuntia fulgida* var. mamillata)

Photo 2. Cholla cactus stem and stem cross section (*Cylindropuntia fulgida* var. mamillata)

Cylindropuntia imbricata **(Haworth) F.M. Knuth 1935.**

Cylindropuntia imbricata is known by several common names, such as “abrojo”, candelabrum cactus, cane cactus, cane chollas, cardenche, “cardón”, chain-link cactus, coyonostyle, “joconostli”, tesajo, “macho”, tree chollas, “vela de coyote”, and xoconostle. The plants are treelike or shrubby, 1-3 m high, and generally with short trunks. Stem segments are cylindrical to somewhat club-shaped, gray-green colored, 8-25 cm long with a diameter of 1.5-4 cm, and with very prominent, widely spaced tubercles (Hernández *et al*., 2008)

They have areoles with yellow to tan wool, aging to back, and elliptical shaped. Glochids are pale yellow and 0.5-3 mm long. They have 5-30 spines on most areoles but do not obscure the stems, the spines silver to yellow to reddish or brown colored, stout, rounded or sometimes flattened in cross-section basally, spreading, straight or curved, with sheaths silver to yellow (Bravo-Hollis, 1978).

Flowers are dark pink to magenta and reddish magenta. Fruits are ovoid, fleshy, yellow, and spineless. They are 2.4-4.5 cm long and have a diameter of 2-4 cm. Two varieties of *C. imbricata* are often recognized. *Imbricate* variety often becomes a tree of 3 m high but has small stem segments. It is distributed in the south-central United States and northern Mexico (Hernández *et al*., 2008). *Argentea* variety is only shrubby but has large stem segments. It occurs only in the Big Bend region of Texas (Anderson *et al*., 2001).

Chemical composition of *Cylindropuntias*, *Opuntias* and Cholla

The chemical composition of cholla stems varies according to age, prevailing climatic conditions, and soil composition. Cactus stems, like any other vegetables, have a low protein and fat content. Its crude fiber is higher than in most vegetables, and it is an important consideration for human health. The nitrogen-free extract content is high and includes soluble and insoluble dietary fiber and sugars. The ash depends on the soil composition, but the main components are calcium and potassium; sodium and phosphorus are present in lesser amounts. Calcium oxalate crystals, which are insoluble in water, increases with age and could constitute up to 85% of ash in old dried stems (Monje and Baran, 2002).

The Table 1 reports the chemical composition of *Opuntia cholla* (Vega-Villasante *et al*., 1997). According to these authors, the samples were collected one week following a 55 mm rainfall event and increased soil moisture may have affected the moisture content of cholla stems. The fluctuation in moisture content may affect the total dry matter of *Opuntia cholla* but does not affect the nutrient composition of the plant.

Additional to the chemical composition, Vega-Villasante *et al*. (1997), also studied the enzymatic activity (protease and amylase activity) of the plant extracts. Other authors such as Sawyer *et al*. (2001) have reported the chemical composition of a cholla spp., they reported a 12.5% of dry matter content in cholla cactus (*Cylindropuntia imbricata*).

Table 1. Chemical composition of *Opuntia cholla*[a].

Constituents	Fresh weight basis cholla stems (g/100 g)
Water	80.4
Carbohydrates	81.53
Ash	4.6–5.6
Fiber	7.2
Protein	3.8
Lipids	1.8–2.6

Source: [a]Vega-Villasante *et al*., 1997.

Ramirez-Orduña *et al*. (2005) reported the variation of the mineral content of legumes and non-legume plants in Baja California Sur, Mexico. One of the non-legume plants was *Opuntia cholla*, Weber (Cactaceae) and the mineral content was studied during three consecutive years. The authors reported that *O. cholla* had the highest Ca content (winter 47.9 g/kg, spring 50.1 g/kg, summer 44.6 g/kg, and autumn 41.2 g/kg); it is higher than the value reported by Ramirez *et al* (2001) for *O. engelmannii* with a Ca content of 26.7 g/kg.

In the study of Ramirez-Orduña *et al*. (2005) they reported that *O cholla* had a high content of Mg, Mn, and K; in contrast, it has the lowest content of Cu, Zn, and Fe. The authors indicate that the content of these minerals is affected by climatic conditions. Furthermore, animals to be fed with this cactus usually could not require supplementary Ca, Mg, Na, and K; because the main minerals are supplied by *O cholla* during most of the year.

Colchero (2009) reported the phytochemistry of roots from *O. cholla* Weber (E-240), the author used column chromatography for separation of extracts (solvents methanol and hexane) and the characterization of the metabolites was performed by NMR ^{1}H and ^{13}C. The phytochemical analysis identified the presence of alkaloids, flavonoids, tannins, coumarins, and glucosides. In the methanolic extract was observed the presence of steroids and aromatic derivate associated with sugars.

Type of carbohydrates, sugars, and organic acids

The majority of carbohydrates in cholla, as in all cacti, are found as high molecular weight compounds like cellulose, hemicellulose, and lignin, as cell wall constituents and those that constitute the gums or mucilage for water storage purposes. Maceda *et al.* (2018), report wood differences of cactaceous *Cylindropuntia* and *Opuntia* species, principally in cellulose, lignin, and hemicellulose, with more content of lignin *Cylindropuntia*.

The composition of cholla mucilage has been studied since the early years of the last century. Several approaches to determine the monomer composition had been taken. Sand and Klaas, (1929), reported that cholla gum, now mucilage, was composed of L-arabinose, D-galactose, L-rhamnose, and D-galacturonic acid, after successive hydrolysis and salt formation. Parikh and Jones, (1965), through methylation oxidations and partial hydrolyzes, determined that mucilage was composed of L-arabinose, D-galactose, D-xylose, L-rhamnose, and D-galacturonic acid. Table 2 shows the percentages of dry cholla gum that has been reported for *Opuntia ficus indica* and cholla.

The cholla, like cacti and many desert shrubs, is adapted to minimize water loss (e.g. having small leaves or photosynthetic stems) or present succulent tissues to store water. Many of these plants also have a crassulacean acid metabolism (CAM), a specific adaptation for conserving water. In CAM plants, the stomata remain closed by day preventing water loss, but open at night to receive CO_2. The CO_2 is combined with the 3-carbon compound phospho-enol-pyruvate to form 4-carbon organic acids such as oxaloacetic acid and malic acid. Essentially, this is an adaptation for CO_2 storing (Nordal, *et al*., 1965).

Subsequently, during the day (when the stomata are closed), CO_2 is released from the organic acids and used for sugar synthesis in the Calvin cycle. Other organic acids that could be expected in cholla are phorbic and psicidic acids that are commonly found in plants exhibiting CAM metabolism, which have been reported in *Opuntia ficus indica* by Nordal *et al*. (1965).

Table 2. Comparison of the percentages of dry cholla gum composition with that reported for *Opuntia ficus-indica*[a].*

Carbohydrate	*Opuntia ficus-indica*[a]	Cholla (ND)[b]	Cholla (*O. fulgida*)[c]
Galacturonic acid	8	––	9.2
Uronic acid	––	11	––
Arabinose	42	53	51.6
Xylose	22	––	15
Galactose	21	8.4	31.7
Rhamnose	7	5.5	2–3

* Values as percentages on a dry weight basis. N.D. Not determined. [a]Nobel *et al*., 1992; [b]Sand and Klaas, 1929; [c]Parikh and Jones, 1965.

Type of proteins, enzymes, amino acids

Vega-Villasante *et al*. (1997), studied the nutritional quality of cactus and other desert plants, including *Opuntia cholla*, and observed very low protein levels (3.8%). However, despite the low protein content of cholla, it can be used as a complementary food for cattle because of its high content of water and carbohydrates. In addition to the above, they also analyzed protease, amylase, and lipase activity. The authors reported that under their experimental conditions, there was a decrease in the enzymatic activity by the *Opuntia* cholla extract. Their results showed not detection of protease activity, while amylase presented low activity when measured by absorbance at 550 nm using soluble starch as substrate. Lipase activity was also detected with low activity when measured by absorbance at 540 nm using β-Naphthyl as substrate. Other researchers (Stintzing and Carle, 2005) have described protein crude content of 13 to 13.6% for prickly pear cactus or cholla. As a prickly pear, location and species may be important determinants of cholla quality.

Minerals

Generally, the ash content of cacti is variable and quite high. Stintzing *et al*. (2001), reported that the cactus pear is rich in magnesium and calcium, whereas levels of sodium, potassium, iron, and phosphorus, are in the typical range of fruits. Other reports indicate that potassium is the main mineral with about 60% of total ash content, followed by calcium, sodium, and iron, while magnesium was not detected (Stintzing and Carle, 2005). These authors reported that mineral values should be considered estimations since mineral contents vary within species, site of cultivation, and the physiological state of cladode tissue. Bravo-Hollis, (1978), stated that the main mineral components in *Opuntia* ashes are calcium, potassium, magnesium, and sodium, which are usually found as salts and silica. Moreover, this author mentioned that is possible to find traces of iron and aluminum. The high ash content of cacti is reflected by an accumulation of mineral. The mineral content specifically for cholla is shown in Table 3.

Table 3. Selected mineral composition of unburned and burned cholla cactus.

	Treatment	
Mineral (units)	**Unburned**	**Burned**
Calcium (%)	4.56	4.85
Phosphorus (%)	0.16	0.17
Potassium (%)	2.08	2.19
Magnesium (%)	0.61	0.66
Manganese (ppm)	75.2	73
Copper (ppm)	5	4.8
Aluminum (ppm)	115.6	91.8
Zinc (ppm)	24.4	10.6

Sawyer *et al*. (2001).

Type of lipids and waxes

Among the few reports regarding *Cylindropuntia*'s seeds oil is the Prieto-García *et al*. (2008), study the fat content of *Cylindropuntia imbricata* and *Cylindropuntia matudae* sp was 16.73 and 18.31% (dry matter basis), and the water content of the seeds was 1.85 and 3.01%, respectively. These values are higher than those reported above for the *Opuntia* prickly pear seeds. Regarding the presence of wax in cholla, *Opuntia imbricate* [Haw] DC (walkingstick cholla), Endecont *et al*. (2005) reported that the outside covering of this type of cholla is composed of a very dense waxy cutin, difficult to penetrate and reduce the particle size during mastication when it is used in animal diet.

Other compounds

It is important to understand that all concentrations can be highly variable due to many factors such as genetics, environment, age, part sampled, weather, health, season or time of day, and whether the plants were wild or cultivated. These factors are potentially capable of influencing the alkaloid content and/or composition in plants. Quercetin-3-rutinoside, Quercetin-3-glucoside and Kaempferol- 3-glucoside (flavonoids) were reported in the flowers 3,4-Dimethoxyphenethylamine (around 0.01%), 4-Hydroxy-3,5-dimethoxyphenethylamine (Less than 0.01%), Mescaline (0.01%) in dry matter basis (Trout, 2014).

CONCLUSION

A comprehensive overview of some *Cylindropuntia spp* has been presented, describing its botanical and chemical composition (carbohydrate, sugar, organic acid, proteins, minerals, and bioactive compound). The current overview has pointed out the dispersed information in the literature about this Cactaceae. For several years Indian groups have developed the traditional usage of the cholla species, for a wide variety of therapeutic, prophylactic, source of carbohydrate and bioactive compounds. However, more research is needed for a broader study of its biological and chemical properties. In order to develop novel therapeutic applications from the view of the traditional use reported in this paper, it is important that further research must be performed to develop suitable and appropriate policies and protocols in chollas species for herbal medicine.

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