Review [Revisión]

Argemone ochroleuca: (PAPAVERACEAE), ALKALOID POTENTIAL SOURCE FOR AGRICULTURAL AND MEDICINAL USES †

[*Argemone ochroleuca*: (PAPAVERACEAE), FUENTE POTENCIAL DE ALCALOIDES PARA LA AGRICULTURA, Y USO MEDICINAL]

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SUMMARY

Background. The genus Argemone contains 24 species, *A. ochorleuca* is present in national territory and is used in agriculture and traditional medical treatments for various conditions. **Results**. *A. ochorleuca* is an herbaceous and/or perennial plant that blooms all year. This plant had the potential as a source of benzyl isoquinoline alkaloids, which are the main bioactive compounds responsible for antibacterial, antifungal properties. However, some of these compounds are associated with toxic effects too. Information about concentrations and parts of the plant it is important for all uses and applications. **Implications**. The present work summarizes available information on phytochemical and medicinal properties. **Conclusion**. In *A. ochrolecuca*, six of the 45 alkaloids reported for the genus Argemone have been studied, dihydro-keleritrin and dihydro-sanguiranine are the most abundant in the seeds and vegetative tissue of the species. The updated information should be useful to guide future research on this plant.
Keywords: Alkaloids; papaveraceae; berberine; sanguinarine.

RESUMEN

Antecedentes. El género Argemone contiene 24 especies, *A. ochorleuca* está presente en gran parte del territorio nacional y se utiliza en la agricultura y como planta medicinal para el tratamiento de diversas afecciones **Resultados**. *A. ochorleuca* es una planta herbácea y/o perenne que florece todo el año y tiene potencial como fuente de alcaloides del tipo bencilisoquinolina, que son los principales compuestos bioactivos responsables de las propiedades antibacterianas, antifúngicas. Sin embargo, algunos compuestos están asociados con efectos tóxicos, dependiendo de sus concentraciones y partes de la planta donde se encuentran. **Implicaciones.** El presente trabajo resume información sobre las propiedades fitoquímicas y medicinales. **Conclusión.** En *A. ochrolecuca*, se han estudiado seis de los 45 alcaloides reportados para el genero Argemone. La dihidro-queleritrina y la dihidro-sanguiranina son los más abundantes en las semillas y tejido vegetativo de la especie. La información actualizada debe ser útil para guiar futuras investigaciones sobre esta planta.
Palabras clave: Alcaloides; papaveráceas; berberina; sanguinarina.

INTRODUCTION

Argemone ochroleuca Sweet is an herbaceous Mexican plant of the Papaveraceae family, with annual or perennial growth habit and a wide distribution in the Americans (Ownbey, 1958). This herb is designated an invasive species in Africa and Asia (Berhanu, 2007). The genus *Argemone* contains 24 species, including *A. Mexicana* and *A. ochroleuca*, which are considered medicinal species with bactericidal properties (Sharma *et al*., 2011, 2017). These properties are associated with phytochemicals, such as the alkaloids sanguinarine and berberine, which are responsible for bactericidal activity and have been tested against human pathogenic bacteria (Alamri and Moustafa, 2010; Bhattacharjee *et al*., 2010; Reyes *et al*., 2011), and flavonoid compounds with antioxidant activity (Al-Madhagi *et al*., 2016).

In Mexico, *Argemone* flowers are present during the entire year (Martínez, 1996; Rzedowski and Rzedowski, 2001). Their availability enhances their

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potential as a source of phytochemicals for botanical or biorational pesticides. The phytochemical compounds present in *Argemone* have been shown to have biological activity against agricultural pathogens, including fungi, bacteria and viruses. Moreover, such compounds are biodegradable, so they may not signifcant environmental effects, and may be subjects of fewer toxicological restrictions and consequently have lower development costs (Isman and Seffrin, 2014).

Research on phytochemicals present in *Argemone* has so far focused on *A. mexicana* (Priya and Rao, 2012; Singh *et al*., 2012; Brahmachari *et al*., 2013; Joshi *et al*., 2013; Al-Madhagi *et al.,* 2016). Studies on *A. ochorleuca* are scarce and scattered, though in several studies its identity may have been mistakenly reported as *A. mexicana*. The objective of this review is to synthesize the available research on the phytochemicals present in *Argemone* specially *A. ochorleuca*, for their potential industrial, pharmacological, and agricultural uses.

Origin and Distribution

Argemone is a genus exclusive to the American continent, except for the native species of the Hawaiian Islands. The species *A. mexicana* was dispersed in the tropical and subtropical regions, while *A. ochroleuca* was dispersed in Australia. Aside from being aided by water and wind, seed dispersal has been aided by human activity, mainly because it is used as a medicinal plant (Ownbey, 1958).

The first species of *Argemone* known to science was *A. mexicana* which was grown by John Gerard from seeds brought to him from St. Johns Island, West Indies, in 1592. Was the first to publish a description of the species, under the name *Papaver spinosum*. His description was followed a year later by that of Gerard in 1597, who illustrated and discussed the species under the name *Carduus chrysanthemus perunus*. Subsequently the species of the genus argemone described from cultivated plants were: *A. platy waxes* Link and Otto in 1830; *A. ochroleuca* Sweet in 1829, *A. grandiflora Sweet* in 1829 and *A. intermedia* Sweet in 1830 (Ownbey, 1958; Gerard, 2015). *A. ochroleuca* was introduced into Europe before 1790, but was not continued in cultivation. Prain 's basis for this statement was a specimen cultivated at Paris in the eighteenth century and preserved in the A. L. Jussieu herbarium. The species was again introduced, into England, in 1827 according and has since remained in cultivation (Ownbey, 1961).

About 18 species of *Argemone* were reported in Mexico, the most frequently reported being *A. mexicana*, *A. ochroleuca*, and *A. platyceras* (Villaseñor, 2016). The high degree of specialization of *Argemone* is mostly due to geographical isolation, which may have lead to divergence through reproductive isolation and polyploidy. Indeed, *A. ochroleuca* was hypothesized to have been derived from *A. mexicana* through polyploidy because of the degree of crossing compatibility between the two species (Ownbey, 1958).

A. ochroleuca grows between 1700 and 2200 m above sea level, and from central Mexico to the southern United States. It is easy to see along roads, in agricultural fields, and vacant lots (Schwarzbach and Kadereit, 1999). Both *A. mexicana* and *A. ochroleuca* are considered weeds plants because they are present in farmland, disturbed areas, and in the vicinity of road and water ways. Where they are invasive, such as in South Africa, they represent dual threats because they compete with native flora and are toxic to vertebrates, thus they have been subjects of chemical and biological control efforts (Mpedi and Van der Westhuizen, 2011; Namkeleja *et al*., 2014).

Botanical Description

Argemone ochroleuca (Figure 1) is a herbaceous, annual or short-lived perennial plant, is glaucous, with yellow or orange latex, and its stem bares straight spines of different lengths, widely spaced and perpendicular to the surface from which they originate; a simple or branched stem at the top; leaves often arranged in a rosette in the basal part of the plant, oblanceolate to elliptical (Rzedowski and Rzedowski, 2001). *A. ochroleuca* has cylindrical floral buttons measuring 8 to 18 mm in length, and 4 to 11 mm wide. Its sepals hold at least three fine spines each, divergent apical horns, plump or somewhat flattened, and triangular-subulled. Flowers measure 5 to 12 mm in length, including the terminal spine. Petals are cream or sometimes white, obovate or obcuneiform to elliptical, 1.5 to 35 mm long and 3 to 25 mm wide. Stamens number from 20 to 75, with yellow filaments and anthers; purple stigma, 2.0 to 3 mm wide and 1 to 1.5 mm long. Between their extended lobes they show bluish non-receptive zones, usually clearly visible. The fruits are capsules of 3 to 6 carpels, from 2 to 5 cm long, including style and stigma, and from 1 to 2.5 cm wide (without taking into account the spines). The spines of the fruit are spread out and scattered, the longer spines measuring from 6 to 12 mm long, and sometimes mixed with smaller spines. The seeds are small, 1.5 to 2 mm in diameter (Calderón, 1991) show dark brown color, with a sphere shape and rough surface.

Figure 1. A, B) Plant and flower of *Argemone ochroleuca*, C) Floral buttons and ramified stems collected in Irapuato, Guanajuato, Mexico.

Two subspecies of *A. ochroleuca* are recognized (Ownbey, 1958; Calderón, 1991):

a) *A. ochroleuca*. ssp. *ochroleuca* develops flower buds, excluding sepals horns, 15 to 18 mm long and 8 to 11 mm in diameter; petals are wide, obcuneiform, lemon-yellow color, and measure more than 1.0 cm. Flowers of 4 to 7 cm in diameter.

b) *A. ochroleuca*. ssp. *stenopetala* develops flower buds, excluding sepals horns, 8 to 12 mm long and 4 to 6 mm in diameter; petals are closely elliptical, lemon-yellow color, and measure less than 1.0 cm wide. Flowers of 3 to 5 cm of diameter.

Argemone produces several alkaloids of the benzylisoquinoline type (BIA), some of which, can be toxic due their effects on the central nervous system, including loss of coordination, drowsiness and seizures. However, the same alkaloids have valuable applications, such as pesticides (Ziegler and Facchini, 2008), antibacterial (Alamri and Moustafa, 2010) antifungal (Siddiqui *et al*., 2002) or medical applications against different diseases such cancer (Chang *et al*., 2003; Sharma *et al*., 2011), gastrointestinal and bacterial infections (Gobato *et al*., 2015; Singh *et al*., 2012; Fletcher *et al*., 1993)

Benzylisoquinoline (BIA) type alkaloids

There is a diversity of benzylisoquinoline (BIA) type alkaloids, comprise about 2500 known structures, over 90% of the plants that produce BIAs, are found in members of the basal angiosperm families *Papaveraceae*, *Berberidaceae*, *Menispermaceae*, *Ranunculaceae* and *Magnoliaceae* (Desgagné and Facchini, 2011). BIA diversity results from modification of a basic carbon skeleton consisting of an isoquinoline and a benzyl moiety (Ziegler et al., 2009), which is the building block in the formation of several structural categories of including aporphines, benzophenanthridines, bisbenzylisoquinolines, protopines, protoberberines and morphinans

BIA alkaloids biosynthesis

Most research on BIA metabolism has targeted biosynthetic enzymes and corresponding genes involved in forming only a few compounds in a restricted number of species. Six main sources of biosynthetic genes are opium poppy (*Papaver somniferum*), *California poppy* (Eschscholzia californica), Mexican prickly poppy (*Argemone mexicana*), Japanese goldthread (*Coptis japonica*), meadow rue (*Thalictrum flavum*), and barberry (*Berberis wilsoniae*). The major compounds in opium poppy include morphinan type alkaloids, from the diversity of those compounds, only sanguinarine and related benzophenathridine alkaloids and are major compounds found in california poppy and Mexican prickly poppy, which also produces protoberberine alkaloids like berberine (Dang *et al.*, 2012).

BIA biosynthesis begins with a metabolic lattice of decarboxylations, orthohydroxylations, and deaminations that convert tyrosine to both dopamine and 4- hydroxyphenylacetaldehyde .The only enzyme involved in these early steps that has been purified, and for which the corresponding cDNA has been cloned, is the aromatic L-amino acid decarboxylase (TYDC) that converts tyrosine and dopa to their corresponding amines (Facchini, 2001). Dopamine is the precursor for the isoquinoline moiety, and 4-hydroxyphenylacetaldehyde (4-HPAA), the deamination product of tyramine, is incorporated into

the benzyl component (Facchini and De Luca, 2008) Subsequent deriven in (S)-reticuline, the central intermediate leading to most BIA structural subgroups (Dang et al., 2012).

The alkaloid (S)-reticuline is well known to be the common precursor to the majority of BIAs (Deng et al., 2018). The first committed step in benzophenanthridine and protoberberine alkaloid biosynthesis is catalyzed by the FAD-dependent oxidoreductase berberine bridge enzyme (BBE), which catalyzes stereospecific oxidation and methylene bridge formation of (S)-reticuline to yield (S)-scoulerine. The biosynthesis of benzophenanthridines such as sanguinarine begins with the consecutive formation of two methylenedioxy bridges in (S)-scoulerine by the cytochromes P450 (S)-cheilanthifoline synthase (CFS) and (S)-stylopine synthase (STS), Subsequently, dihydrosanguinarine is converted to sanguinarine by dihydrobenzophenanthridine oxidase (DBOX) after sanguinarine reductase(SanR) purified sanguinarine at the end of the reaction (Desgagné and Facchini, 2011).

The BIA alkaloids in industry is in constant development, at the moment, most of the alkaloids are recovered form plant tissues, there is new investigations through microbial and yeast production (Schläger and Dräger 2016) but is still in lab probe, meanwhile it is important to find novel sources of BIA alkaloids like *Argemone* species.

Biological activities of *Argemone*

In traditional medicine, there is evidence of *Argemone* was used by Mesoamerican cultures in Central Mexico and beyond 3000 years before present (Reyna-Robles and Gonzalez-Quintero, 1978; Lozoya, 1999). Edible and medicine plants were mixed with *Argemone*. In Mexico, North Africa, and India, the plant is recommended to treat glaucoma, tachycardia, dermatological ailments, eye infections, and coughs (Argueta y Cano, 1994, Rubio-Piña and Vázquez-Flota, 2013). Brahmachari et al. (2013) reported 45 alkaloids that are synthesized in the various organs of *Argemone mexicana* and *A. ochroleuca* plants (Table 1).

Table 1. Principal alkaloids present in *A. mexicana* and *A. ochroleuca* (Papaveraceae).

Alkaloid	Part of plant	Species	Reference
(-)-argemonine	*Resin*	*A. mexicana*	Rahman, 1994;
(±)-cheilanthifoline	*All plant*	*A. mexicana*	Haisová and Slavik, 1975; Israilov *et al*., 1986; Tripathi *et al*., 1999
(-)-scoulerine	*Aerial parts*	*A. mexicana*	Israilov *et al*., 1986; Haisová and Slavik, 1975
(-)-stylopine (	*All plant*	*A. mexicana*	Haisová and Slavik, 1975
(-)-tetrahydroberberine	*All plant*	*A. mexicana*	Chang *et al*., 2003a
(+)-argenaxine	*Aerial parts*	*A. mexicana*	Chang *et al*., 2003a
(+)-higenamine	*Aerial parts*	*A. mexicana*	Chang *et al*., 2003a
(+)-reticuline	*Apical and aerial parts*	*A. mexicana*	Israilov *et al*., 1986; Chang *et al*., 2003a
(±)-6-acetonyl dihydrochelerythrine	*All plant*	*A. mexicana*	Chang *et al*., 2003b; Nakkady *et al*., 1988
(±)-tetrahydrocoptisine	*All plant*	*A. mexicana*	Singh *et al*., 2010b
13-oxoprotopine	*Aerial parts*	*A. mexicana*	Singh *et al*., 2012
8-acetonyl dihydrosanguiranine	*All plant*	*A. mexicana*	Nakkady *et al*., 1988
8-methoxy dihydrosanguiranine	*Aerial parts*	*A. mexicana*	Singh *et al*., 2012
allocryptopine	*Apical parts*	*A. mexicana*	Haisová and Slavik, 1975; Israilov *et al*., 1986; Chang et al., 2003
angoline	*All plant*	*A. mexicana*	Chang *et al*., 2003b
argemexicaine A	*All plant*	*A. mexicana*	Chang *et al*., 2003a
argemexicaine B	*All plant*	*A. mexicana*	Chang *et al*., 2003a
argemexirine	*All plant*	*A. mexicana*	Singh *et al*., 2010a
arnottianamide	*All plant*	*A. mexicana*	Chang *et al*., 2003a
berberine	*Apical parts, seed*	*A. mexicana, A. ochroleuca*	Haisová and Slavik, 1975; Fletcher *et al*., 1993; Chang et al., 2003a.
chelerythrine	*All plant*	*A. mexicana A.ochroleuca*	Fletcher *et al*., 1993; Chang *et al*., 2003a

Alkaloid	Part of plant	Species	Reference
columbamine	*All plant*	*A. mexicana*	Singh *et al*., 2010a
coptisine	*All plant*	*A. mexicana*	Chang et al., 2003a
cryptopine	*All plant*	*A. mexicana*	Haisová and Slavik, 1975
dehydrocheilanthifoline	*All plant*	*A. mexicana*	Chang *et al*., 2003a
dehydrocorydalmine	*All plant*	*A. mexicana*	Singh *et al*., 1999; Singh e*t al*., 2009
dihydro-chelerythrine	*Vegetative tissue, seeds*	*A. mexicana, A. ochrolecua*	Takken *et al*., 1993; Chang *et al*., 2003a.
dihydrocoptisine	*All plant*	*A. mexicana*	Singh *et al*., 2010a
dihydropalmatine hydroxide	*Seeds*	*A. mexicana*	Ito *et al*., 1990
dihydrosanguiranine	*Seeds*	*A. mexicana, A. ochrolecua*	Fletcher *et al*., 1993; Takken *et al*., 1993; Chang *et al*., 2003a
isocorydine	*Apical parts*	*A. mexicana*	Israilov *et al*., 1986
jatrorrhizine	*All plant*	*A. mexicana*	Singh *et al*., 2010a
muramine	*All plant*	*A. mexicana*	Nakkady *et al*., 1988
N-demethyloxysanguinarine	*Aerial parts*	*A. mexicana*	Chang *et al*., 2003a
nor-chelerythrine	*All plant*	*A. Mexicana B.*	Haisova and Slavik, 1975
nor-sanguinarine	*All plant*	*A. mexicana*	Haisová and Slavik, 1975; Tripathi *et al*., 1999; Rahman, 1982
O-methylzanthoxyline	*All plant*	*A. mexicana*	Chang et al., 2003a
oxyberberine	*All plant*	*A. mexicana*	Singh *et al*., 2010a
oxyhydrastinine	*All plant*	*A. mexicana*	Nakkady *et al*., 1988
pancorine	*Aerial parts*	*A. mexicana*	Chang *et al*., 2003a
protomexicine	*Aerial parts*	*A. mexicana*	Singh *et al*., 2012
protopine	*Apical parts and seed*	*A. mexicana, A. ochroleuca*	Haisová and Slavik, 1975; Israilov *et al*., 1986; Fletcher *et al*., 1993
sanguinarine	*Seed*	*A. mexicana, A. ochroleuca*	Fletcher et al., 1993; Sakthivadivel and Thilagavathy, 2003; Singh and Singh, 1999.
thalifoline	*All plant*	*A. mexicana*	Nakkady *et al*., 1988

The alkaloids are presented in more than 20% of the species of flowering plants, their biosynthesis and accumulation in tissues are associated with defense mechanisms; acting as toxins against herbivores and pathogens (Shoji, 2017). Usually, the plants produce several groups of alkaloids and their distribution can be in the whole plant or restricted to specific organs such as roots, rhizomes, stem bark, leaves, fruits or seeds (Daniel, 2006) and can be used for different purposes (Figure 2).

Biological activities in of *A. ochroleuca*

In the case of *A. ochroleuca,* the aerial parts have been used as an analgesic, narcotic and hallucinogen agent (Gurib-Fakim *et al*., 2003). The presence of the benzylisoquinoline type alkaloids (BIAs) the sanguinarine (S) y dihidrosanguinarine (DHS) can account for their medicinal effects given their antimicrobial and cytotoxic properties (Guízar-González *et al*., 2012; Moustafa *et al*., 2013).

The raw latex of *A. ochroleuca* was shown to have *in vitro* antibacterial effects against *Bacillus subtilis*, *Escherichia coli*, *Enterobacter aerogenes*, *Micrococcus luteus*, and *Staphylococcus aureus* (Alamri y Moustafa, 2010). The alkaloids sanguinarine and berberine affect both gram positive and gram negative bacteria by interfering with the assembly of the FtsZ protein in the filaments that make up the contraction belt in the middle part of cells, hindering bacterial fission or increasing membrane permeability and the intercalation of bacterial DNA (Lewis y Ausubel, 2006; Domadia et al., 2008; Mingorance *et al*., 2010). Sanguinarine increases the sensibility of *S. aureus* to the β-lactamics antibiotics (Obiang-Obounou et al., 2011). Indeed, this alkaloid can be used in mouth rinses and toothpastes as an anti-plaque agent, though its use is highly restricted because of its

association with leucoplast lesions associated with oral cancer. *Argemone* extracts are active at lower doses for their antibacterial properties compared to other plants, such as *Sapindus emarginatus*, *Mirabilis jalapa*, *Rheo discolor*, *Nyctanthes arbortristis*, *Colocasia esculenta*, *Gracilaria corticata*, and *Pulicaria wightiana* (Nair *et al*., 2005; Rubio-Piña and Vázquez-Flota, 2013). The methanolic and aqueous extracts of seeds and leaves showed antibacterial activity against *Staphylococcus aureus* and *Bacillus subtilis*, as well as *Escherichia coli* and *Pseudomonas aeruginosa* (Bhattacharjee *et al*., 2006), *Salmonella typhy* (Gehlot and Bohra, 2002), and *Mycobacterium tuberculosis* (Mishra *et al*., 2017).

Table 2. Biological activity from *Argemone* (Papaveraceae) alkaloids.

Alkaloid	Biological activity	Reference
(-)-argemonine	Inhibition of virus; anti-proliferative cancerous;	Ruchirawat and Namsa-Aid. 2001; Leyva-Peralta *et al*., 2015
(±)-cheilanthifoline	Antibacterial activiti	Wangchuk *et al*., 2016
(-)-scoulerine	Sedative and muscle relaxing agent	Schrittwieser *et al*., 2011
(-)-stylopine	Anti-inflammatory	Jang *et al*., 2004
(-)-tetrahydroberberine	Cytotoxic and antioxidant activity	Pingali *et al*., 2015
(+)-argenaxine	Cytotoxic activity	Chang *et al*., 2003a
(+)-higenamine	Cytotoxic activity	Chang *et al*., 2003a
(+)-reticuline	Cytotoxic activity	Chang *et al*., 2003a
(±)-6-acetonyl dihydrochelerythrine	Anti-HIV activity	Chang *et al*., 2003b
(±)-tetrahydrocoptisine	Anti-inflammatory	Li *et al*., 2014b
13-oxoprotopine	Cytotoxic activity	Sing *et al*., 2016a
8-acetonyl dihydro sanguiranine	Antibacterial activity	Zuo *et al*., 2009
allocryptopine	Effect on ileum in guinea pig; Antimalarial activity	Capasso *et al*., 1997; Piacente e*t al*., 1997;
angoline	Cytotoxic activity	Sharanappa and Vidyasagar, 2014.
berberine	Anti-fertility activity; Effect on ileum contraction in guinea pig; Antimalarial activity	Gupta *et al*., 1990; Piacente et al., 1997
chelerythrine	Cytotoxic activity	Chang *et al*., 2003a
coptisine	Antidiabetic, antimicrobial and antiviral	Li *et al*., 2014a
dehydrocheilanthifoline	antimicrobial activities	Ali *et al*., 2013
dehydrocorydalmine	Antifungal activity	Singh *et al*., 2009
dihydropalmatine hydroxide	Anti-fertility activity	Gupta *et al*., 1990
isocorydine	Anticancer activities	Zhong *et al*., 2014
jatrorrhizine	Neuroprotective effects	Luo *et al*., 2012
N-demethyloxysanguinarine	Cytotoxic activity	Chang *et al*., 2003a
oxyberberine	Antidiabetic effects; Antifungal activity	Singh *et al*., 2009
pancorine	Cytotoxic activity	Chang et al., 2003a
protopine	Anti-fertility activity; Effect on ileum in guinea pig; Mollucicidal activity; Antimalarial activity	Gupta *et al*., 1990; Capasso *et al*., 1997; Piacente *et al*., 1997; Singh and Singh, 1999; Simoes-Avello, 2009
sanguinarine	Mollucicidal activity	Singh and Singh, 1999

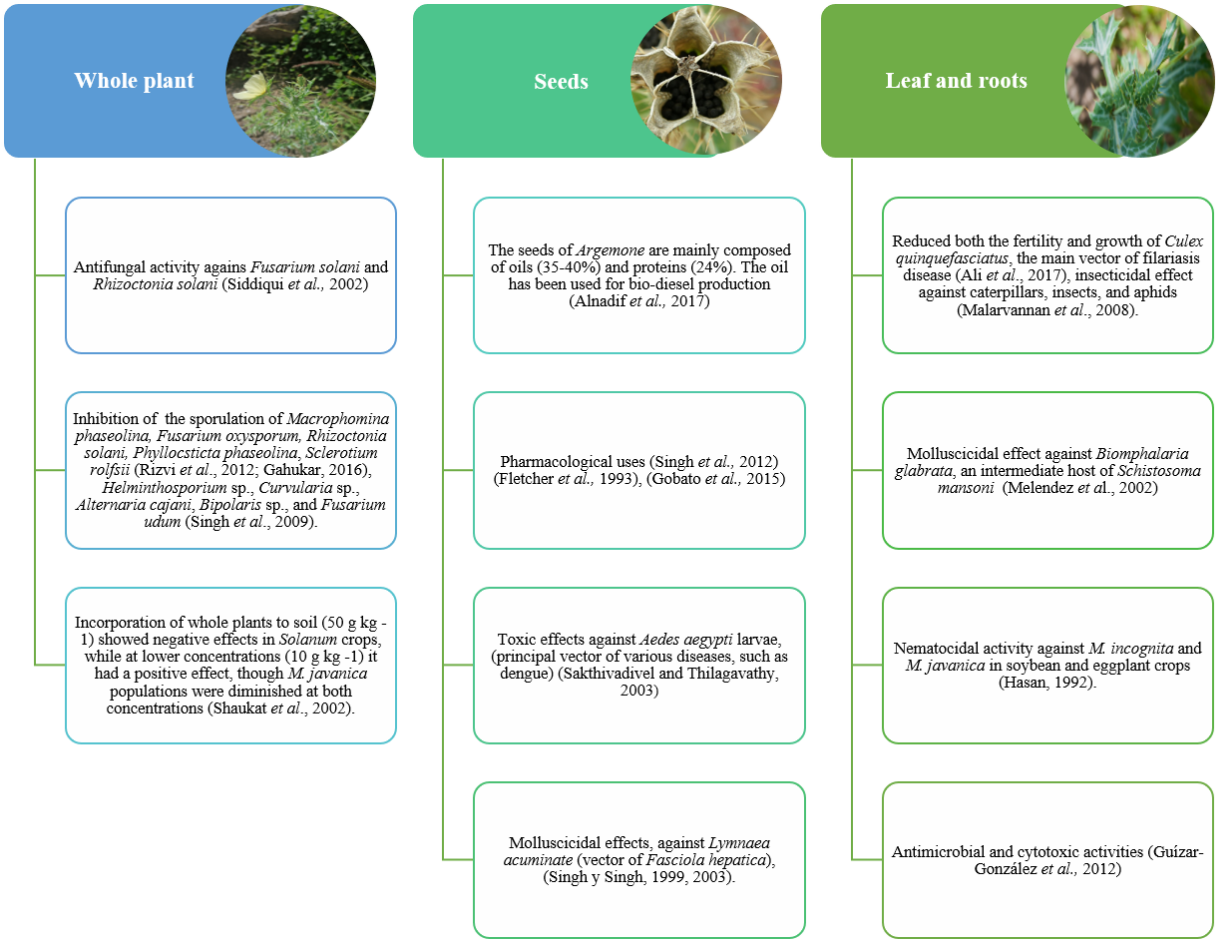

Figure 2. Principal uses of vegetative parts of *A. ochroleuca* plants.

The alkaloid protopine, may be related to anticholinergic effects (Üstünes *et al*., 1988) because it inhibits the activity of acetylcholine on the nervous system. This alkaloid has a primary role on treatment of depression because it inhibits serotonin and noradrenaline (Xu *et al*., 2006). Berberine may produce muscular spasms and convulsions (Xiang *et al*., 2009) by inactivating acetylcholinesterase. Similarly, high doses of foliar extract had vasodilating effects due to inhibition of angiotensin converting enzyme (Kang *et al*., 2002). In contrast, low doses of leaf extract may increase vascular tension (Páez-Sánchez *et al*., 2006) through their modulatory effect on the brain's neurotransmitters-receptors (Durairajan *et al*., 2012), so may be useful in neurodegenerative and neuropsychiatric diseases (Rubio-Piña and Vázquez-Flota, 2013). On the other hand, *Argemone* extracts shows cytotoxic activity, in gastric and hepatic cancer cells, with chelerythrine (Chang *et al*., 2003; Sharma *et al*., 2011). Sangunarine has shown antineoplastic activity against lymphocytic leukemia and human carcinoma (Ahmad *et al*., 2000; Sharma *et al*., 2011). Indeed, *Achkar et al.*, (2017) noted the potential of sanguinarine for inhibition of cancer cell proliferation in *in* vitro and in vivo tests. In contrast, berberine showed cytotoxic activity by inhibiting adenine translocation (Diogo et al., 2011), and lower side effects, such as vinblastine y paclitaxel (Mazzini *et al*., 2003; Efferth et al., 2005).

CONCLUSION

Argemone is an herbaceous and/or perennial plant that blooms all year that holds potential as a source of alkaloids of the benzylisoquinoline type. Only six of the 45 alkaloids synthesized in the various organs of *Argemone* plants have been studied, all from *A. ochorleuca*. Of those six, dihydro-chelerythrine and dihydro-sanguiranine are the most abundant in seed and vegetative tissue. Which have biological activity related to anti-HIV activity, antibacterial activity, molluscicidal activity and antimalarial activity. The biological activities represented in *A. ochorleuca* is a potential source of alkaloids for medical and agricultural uses.

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Data availability. The data used for the development of this review is available with Jesús Hdz Ruíz, (hernandez.jesus@ugto.mx) upon request.

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