Vol. 3, No. 1, pp. 41-57, (March 2022)
DOI: 10.21608/aujes.2022.109373.1050
Aswan University Journal of Environmental Studies (AUJES)
Online ISSN: 2735-4237, Print ISSN: 2735-4229
Journal homepage: https://aujes.journals.ekb.eg/ E-mail: AUJES@aswu.edu.eg

Review Article

Antileishmanial derivates of natural products from Ricinus communis

Wafaa M. Hikal[1,2], Hussein A. H. Said-Al Ahl[3*]

[1]Department of Biology, Faculty of Science, University of Tabuk, Tabuk, 71421, Saudi Arabia.
[2]Environmental Parasitology Laboratory, Water Pollution Research Department, Environment and Climate Change Institute, National Research Centre (NRC), 33 El–Behouth St., Dokki, Giza 12622, Egypt.
[3]Medicinal and Aromatic Plants Research Department, Pharmaceutical and Drug Industries Research Institute, National Research Centre (NRC), 33 El–Behouth St., Dokki, Giza 12622, Egypt.

Received: 4/12/2021 Accepted: 8/1/2022

Abstract:

Continuous and advanced studies are necessary to explore and meet the continuous need of safe plant compounds necessary for pharmaceutical, therapeutic, food and other industries, especially special phytochemicals to be used as herbal and complementary medicine to combat various diseases and disorders. In this review, we highlight the uses of Ricinus communis in traditional medicine for treatment and others since ancient civilizations and its content of chemical compounds with multiple biological and therapeutic effects, including phenolic compounds, alkaloids, saponins, flavonoids, terpenes and oils and their uses as anti-cancer, antioxidant, anti-diabetic, anti-microbial, insecticide and anti-asthma Anti-ulcers, antimalarials, anti-inflammatories, hepatoprotective, bone regeneration, analgesics and anticonvulsants. It is worth noting that *Ricinus communis* grows in tropical and subtropical regions widely distributed throughout the world and the active substances are found in various parts of the plant, which necessitated that we focus the light on the plant and its multiple benefits and its rich effective compounds to further clinical, experimental and advanced studies to explore more and verify safety prospects.

Keywords: *Ricinus communis*, castor oilseed, *Leishmania*, pharmacology, bioactive compounds, fatty acids, essential oil.

1. An overview of castor (*Ricinus communis*)

There are many sources of treatment in nature, as many medicines depend on natural resources, including plants that are used as a basic source in folk medicine due to plant compounds are of great importance due to their diversity of pharmacological activities (Moreira et al., 2014; Said-Al Ahl et al., 2017; Hikal et al., 2021). Besides, plants are a source of food, fodder and fuel, etc (Fokou et al., 2016; Thomford et al., 2016; Hikal et al., 2017).

Corresponding authors*: E-mail addresses: shussein272@yahoo.com

Herbal medicines derived from plants and their use in treatment as an alternative to chemical medicines are easy to obtain and affordable, while being safe to use (Adaramola et al., 2016; Hamid et al., 2016; Hikal et al., 2020), plant-based bioactive compounds do not have any side effects compared to synthetic drugs and have a wide range of therapeutic applications (Samad et al., 2016; Hikal and Said-Al Ahl, 2019 a and b).

Ricinus communis is an annual oilseed crop, which grows in tropical and subtropical regions widely distributed throughout the world (Junior et al., 2011; Anjani, 2014). Also, Perdomo et al., 2013 showed that oil production seed oil content ranges from 40 to 60% and annual oil production is about 1.8 million tons worldwide. Castor oil is used in agricultural, pharmaceutical and industrial applications. Various castor oil products exist such as ointments, nylon, varnishes, airplane engine lubricants, hydraulic fluids, dyes, detergents, plastics, paints, synthetic leather, cosmetics, and perfumes (Yeboah et al., 2020; Ying et al., 2017) and biofuel/biodiesel production (Worbs et al., 2011; Berman et al., 2011). Residues after oil extraction from castor seeds are a rich source of protein and after detoxification have been used as a food supplement for cattle, sheep, chicken and fish (Gowda et al., 2009; Diniz et al., 2011; Ani et al., 2007), and the use of seed residues as manure or manure (Lima et al., 2011).

Traditionally, various plant parts such as roots, bark, leaves, flowers, stem, seed and seed oil were used for medicinal purposes as a laxative or to treat infections and inflammations, as a remedy for toothache and as a flavoring in ancient civilizations (Abdul et al., 2018; Parkouda et al., 2009). The leaves were also used against jaundice and to relieve stomach pain and flatulence, anti-fungal activity against *Mycobacterium tuberculosis* and yeast and in controlling mosquitoes and repelling aphids, rust mites and whiteflies (Abdul et al., 2018). The seeds were also used for resistance against *Tribolium castaneum* (Adekunle, 2011). In recent years, it has been reported numerous biological activities of *R. communis* plants are antimicrobial, antifungal, anticancer, antidiabetic, anti-inflammatory, antimalarial, antioxidant, central analgesic, anticonvulsant, antinociceptive, anthelminthic, antifertility, laxative, uterine contracting, anti-implantation, antiasthmatic, bone regeneration, molluscicidal, antiulcer, antihistamine, wound-healing, cytotoxic, insecticidal, anti-arthritic, antidandruff and hepatoprotective (Berman et al., 2011). Figure 1 shows the different stages of *Ricinus communis* plant.

Fig.1. Vegetative, flowering and fruiting stages of *Ricinus communis*.

2. Leishmaniases

Leishmaniasis is caused by the Leishmania parasite and is transmitted by more than 20 species of Leishmaniasis known to be infectious to humans by infected female phlebotomine sandflies. There are three main types of leishmaniasis: i) visceral, often known as kala-azar and

the most serious form of the disease (VL); ii) cutaneous, the most common (CL); and iii) mucocutaneous. Leishmaniasis, classified as a neglected tropical disease, is a parasitic disease found in parts of tropical, subtropical and southern Europe as a result of infection with *Leishmania* parasites, which are spread by the bite of infected phlebotomine sand flies. There are several different forms of leishmaniasis in humans. The most common forms are cutaneous leishmaniasis, which causes skin sores, and visceral leishmaniasis, which affects several internal organs (usually spleen, liver, and bone marrow) (CDC, 2020). It is not found in Australia or the Pacific Islands. Also, leishmaniasis is found in some parts of Mexico, Central America, and South America.ó While, Some people have a silent infection, without any symptoms or signs, but the symptoms of cutaneous leishmaniasis can be clarified in the following; one or more sores on their skin. The sores can change in size and appearance over time and may be covered by scab or crust. While, the symptoms of visceral leishmaniasis are fever, weight loss, enlargement (swelling) of the spleen and liver, and abnormal blood tests. People may have low blood counts, including a low red blood cell count (anemia), a low white blood cell count (leukopenia), and a low platelet count (thrombocytopenia). Sand flies become infected by sucking blood from an infected animal or person. Some types (species) of *Leishmania* parasites also may be spread via contaminated needles (needle sharing) or blood transfusions. Congenital transmission (spread from a pregnant woman to her baby) has been reported. The number of new cases may vary or change over time and are difficult to estimate (CDC, 2020; Hikal and Said-Al Ahl, 2017; WHO, 2021). Tables 1-3 show the reported cases for the year 2020 according to the World Health Organization. However, table 4. Show the number of cases of cutaneous leishmaniasis and visceral leishmaniasis reported in Arab Countries (2008 – 2020).

Table 1. Number of cases of cutaneous leishmaniasis globally in 2020.

1	Pakistan	16.770
2	Peru	4.178
3	Egypt	2.239
4	Sri Lanka	2.217
5	Honduras	1.467
6	Saudi Arabia	1.035
7	Ecuador	1.025
8	Panama	938
9	Costa Rica	528
10	Burkina Faso	416
11	Mexico	324
12	Guatemala	121
13	Turkmenistan	107
14	Israel	86
15	Kazakhstan	79
16	Senegal	64
17	Suriname	42
18	El Salvador	38
19	Jordan	23
20	Guyana	12
21	Kuwait	6
22	Bulgaria	1
23	Cyprus	1
24	Montenegro	1
25	Namibia	1
26	Nigeria	1
27	Slovenia	1

Table 2. Number of cases of visceral leishmaniasis globally in 2020.

1	Sudan	2.563
2	India	2.033
3	Eritrea	1.034
4	South Sudan	827
5	Somalia	471
6	China	215
7	Uganda	55
8	Bangladesh	47
9	Georgia	42
10	Greece	34
11	Djibouti	9
12	Albania	6
13	Uruguay	2

Table 3. Total number of cases of cutaneous and visceral leishmaniasis globally in 2020.

		cutaneous leishmaniasis	visceral leishmaniasis	Total
1	Syria	61.559	22	61.581
2	Afghanistan	44.167	١٢	44.179
3	Brazil	16.056	1.954	18.010
4	Algeria	11.566	٣٣	11.599
5	Iraq	8.691	61	8.752
6	Colombia	6.124	8	6.132
7	Tunisia	4.872	28	4.900
8	Yemen	3.605	450	4.055
9	Libya	4.000	24	4.024
10	Morocco	3.774	67	3.841
11	Nepal	3.443	215	3.658
12	Ethiopia	1.402	1.077	2.479
13	Bolivia	2.059	2	2.061
14	Venezuela	1.597	6	1.603
15	Kenya	398	1.178	1.576
16	Uzbekistan	761	47	808
17	Argentina	176	11	187
18	Chad	38	74	112
19	Paraguay	54	26	80
20	France	34	26	60
21	Cameroon	4	٣٣	37
22	Italy	6	29	35
23	Armenia	1	15	16
24	Malta	1	١	2

2.1. Antileishmanial property of *Ricinus communis*

Treatment of leishmaniasis takes a long time and needs frequent and painful injections with high cost, and besides the increasing resistance to common drugs, all of them have increased the complications of treatment of the disease (Sadeghian et al., 2008). Which led to the evaluation of therapeutic methods in the field of herbal products as a result of their benefits and the discovery of their chemical compounds against *Leishmania* infection (Accioly et al., 2012; Date et al., 2007; Corral et al., 2016). *Ricinus communis* have been reported as future alternatives to sand fly control (Sadeghian et al., 2008; Schlein et al., 2001) where, feeding on *R. communis* increases sandfly mortality and causes stomach abnormalities of the parasite (Dinesh et al., 2014). *In vivo* study on *Ricinus communis* ethyl acetate extract revealed the high effectiveness against amastigotes and promastigotes of *Leishmania infantum* and the low cytotoxicity towards

murine monocytic cells (Rondon et al., 2011). Also, Bahmani et al. (2015) explained the antagonistic effect of *Ricinus communis* on cutaneous leishmaniasis.

Table 4. Represent the cases reported by Arab countries during the years 2008 to 2020.

Number of cases of cutaneous leishmaniasis reported [2008 - 2020]													
	2020	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**
Algeria	11.566	10.293	10.847	13.106	10.678	7.523	5.423	6.428	7.418	11.742	10.173	10.666	8.442
Egypt	2.239	1.811	1.161	566	643	2.243	1.444	464	1.260	864	318	174	471
Iraq	8.691	7.056	11.426	18.854	17.566	17.525	2.691	1.648	2.486	2.978	3.113	2.086	1.250
Libya	4.000	6.744	2.977	2.815	2.662	1.632	516	505	1500	1.327	2.273	1.691	1.800
Morocco	3.774	5.455	11.834	6.802	4.903	2.809	2.555	2.592	2.877	4.319	8.707	6.013	5.128
Saudi Arabia	1.035	1.096	921	1.007	1.337	1.490	2.190	1.988	1.464	1.951	4.129	2.549	2.321
Syria	61.559	71.704	80.215	53.232	47.377	50.972	53.876	71.996	55.894	58.156	42.172	46.348	29.140
Tunisia	4.872	7.085	7.467	4.902	6.095	6.611	3.368	4.113	5.376	5.114	3.811	1.737	2.750
Yemen	3.605	4.440	4.763	4.525	9.120	4.063	5.000	3.823	3.629	2.124	3.234	1.801	1.090
Jordan	23	69	150	155	126	70	182	146	103	136	155	148	244
Kuwait	6	-	4	1	7	0	2	14	4	7	12	8	-
Oman	0	0	0	1	1	0	0	-	2	0	3	4	7
Sudan	-	3.299	4.107	3.011	3.503	1.053	336	206	111	752	-	-	-
Lebanon	-	2	0	0	0	3	2	0	2	5	6	1	0
Number of cases of visceral leishmaniasis reported [2008 - 2020]													
	2020	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**
Algeria	33	46	40	34	74	38	30	54	53	89	87	84	84
Egypt	0	0	00		0	0	0	0	0	0	-	-	1
Iraq	61	170	259	172	183	427	362	575	1.045	1.167	1.843	1.549	1.041
Libya	24	28	34	18	10	0	1	12	-	-	-	3	3
Morocco	67	91	106	106	92	81	85	111	113	107	139	134	163
Saudi Arabia	-	0	1	4	4	3	10	5	8	7	8	17	32
Syria	22	47	38	55	25	20	36	30	17	18	19	16	17
Tunisia	28	27	23	23	17	30	44	38	37	55	36	55	63
Yemen	450	132	56	44	0	5	15	-	-	0	-	0	-
Jordan	-	2	1	0	0	0	0	0	0	0	-	-	-
Oman	0	0	0	2	-	1	0	-	1	0	1	1	0
Sudan	2.563	2.851	2.711	3.894	3.810	2.829	3.415	2.389	5.153	7.418	6.957	4.880	3.310
South Sudan	827	1.013	1.867	3.567	4.285	2.840	7.472	2.364	4.353	10.468	9.166	1.907	582
Lebanon	0	0	0	0	0	0	0	2	0	0	-	0	-

Among the results of Jacobson and Schlein (1999) *in vitro*, it was found that *R. communis* extract led to promastigote agglutination and death. Upon infection, the sandfly fed on *R. communis* extract resulting in maximum parasite mortality. The carbohydrates present in the extracts inhibit the agglutination. As well as, Soosaraei et al. [2017] showed that *R. communis* has anti-leishmanial activity. Zarandi et al (2021) explained that the aqueous-alcoholic extract of *R. communis* is effective in killing promastigotes of *L. major*. The extract can exert lethal effects on the flagellate for the content of alkaloids. Jumba et al. (2015) reported the antileishmanial activity of *R. communis* extracts against *L. major in vivo* and *in vitro*. The results obtained showed that, *R. communis* was showed potency against *Leishmania major*, where *R. communis* methanolic extract reduced *L. major* lesion development, which shows its high potential as a candidate for treatment of the *L. major* infection. These findings agree with earlier studies against parasitic organisms of trypanosomatidae (Carneiro et al., 2012; Anthony et al., 2005) and *L. donovani* (Dayakar et al., 2015). Zahir et al., (2012) studied the effect of *R. communis* seeds extract against promastigotes form of *Leishmania donovani*. The results showed that, *R.*

communis seeds has antileishmanial activity against visceral leishmaniasis. Okech et al., (2006) found that aqueous and ethanol extracts of *R. communis* have antileishmanial activity on *Leishmania* promastigotes. Figure 2 shows the major *R. communis* phytochemicals.

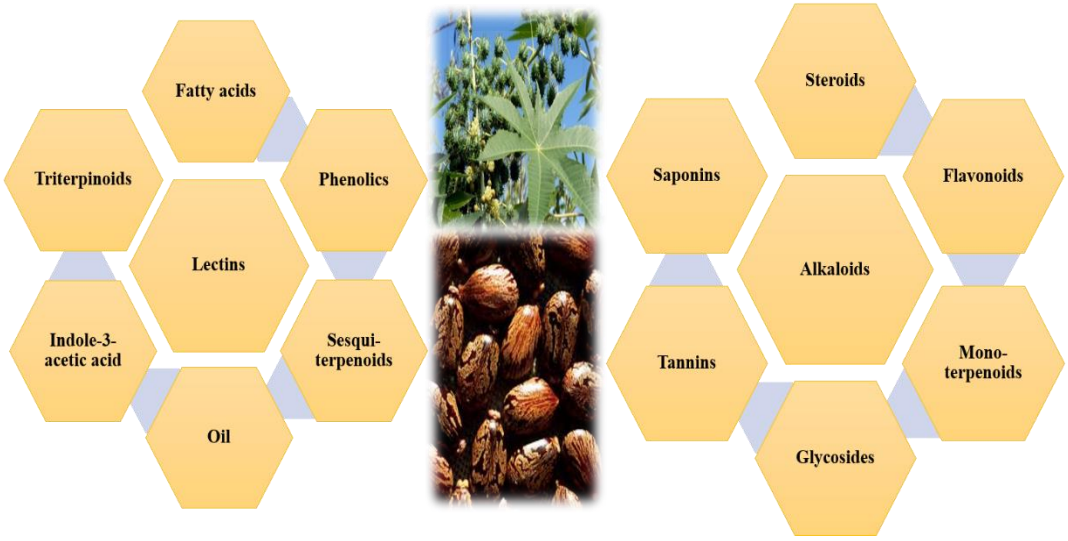

Fig. 2. The major components of *Ricinus communis*.

2.2. *Ricinus communis* chemistry

Previous studies on *Ricinus communis* have indicated the presence of diverse phytochemicals such as flavonoids, terpenes, alkaloids, saponins, tannins, lectins, steroids, glycosides, phenolic compounds such as gallic acid, ricin, kaempferol, rutin, ricinoleic acid, and gentisic acid (Berman et al., 2011; Alugah and Ibraheem, 2014; Zahir et al., 2010; Oyeewole et al., 2010). other studies have also reported on these compounds, kaempferol-3-O-beta-d-rutinoside, kaempferol-3-O-beta-d-xylopyranoside, and kaempferol-3-O-β-D-glucopyranoside (Khafagy et al., 1979), diterpene (ingenol mebutate) (Rinner, 2015) triterpenoids (lupeol, β- and α-amyrin) (Vermeer et al., 2003), gallic acid and quercetin (Ghosh et al., 2013), monoterpene (α-thujone, camphor and β-thujone) chiefly contribute to the anti-inflammatory (Zarai et al., 2012), ricin (Ngo et al., 2016), epicatechin (Zahir et al., 2011), gentisic acid (Singh et al., 2009), catechin (Rondon et al., 2011), ricinoleic acid and linoleic acid (Houbairi et al., 2015), and quercetin-3-O-β-monoterpenoids (Jeyam et al., 2014), indole-3-acetic acid, ricin A, B & C, ricinus agglutinin, and an alkaloid ricinine are the compounds found in castor as mentioned by (Junior et al., 2011; Kang et al., 1985; Darmanin et al., 2009; Singh et al., 2009; Khogali et al., 1992). Aqil et al., (1997) isolated ricinitin, rutin and quercetin-3-o-glucoside from root. This, Berman et al. (2011) attributed the pharmacological and therapeutic effects of castor to those chemical compounds and their anti-cancer, antioxidant, anti-diabetic, and anti-microbial effects in addition to their anti-inflammatory effects, insecticidal, antinociceptive, analgesic, bone regenerative, and anticonvulsant activity. Figures 3 and 4 show the chemical structures of some components in *Ricinus communis*.

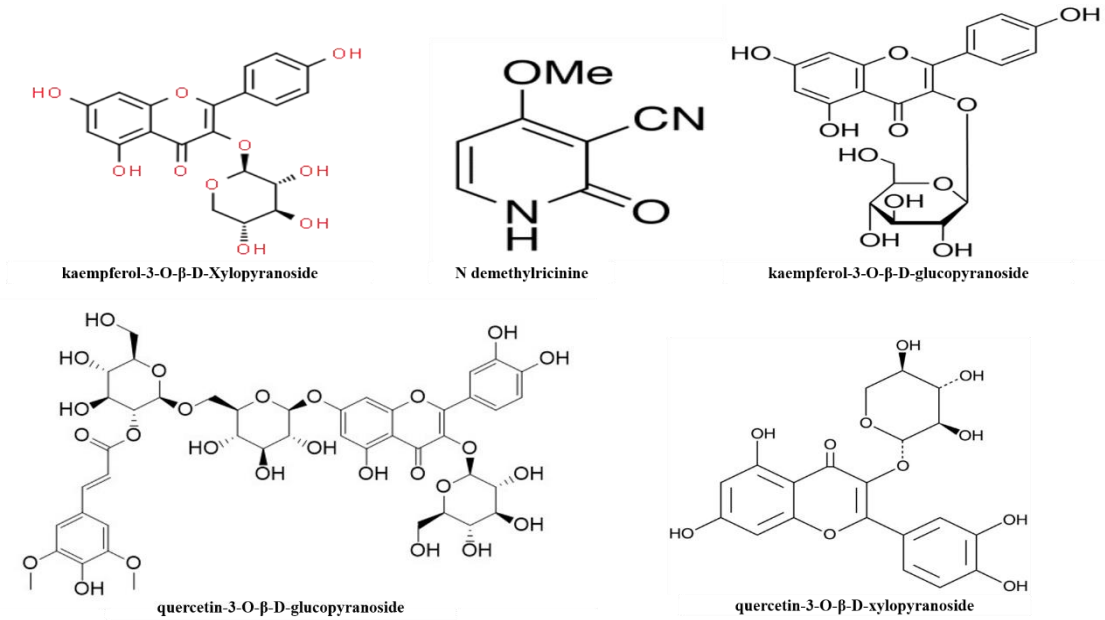

Fig. 3. Chemical structures of some bioactive components in *Ricins communis*.

Chouhan et al., 2021 attribute the medicinal properties of castor to the presence of alkaloids, saponins, steroids, flavonoids, glucosides, and phenolic compounds such as gallic acid, quercetin, rutin, epicatechin, and ellagic acid. In the same context, Rana et al., (2012) showed that the antioxidantو anti-inflammatory properties antidiabetic, antitumour, larvicidal antinociceptive and antiasthmatic activity of the castor are due to its content of gallic acid,quercetin, gentistic acid, tannins and alkaloid. The same results were obtained by (Kang et al., 1985; Singh et al., 2009; Darmanin et al., 2009).

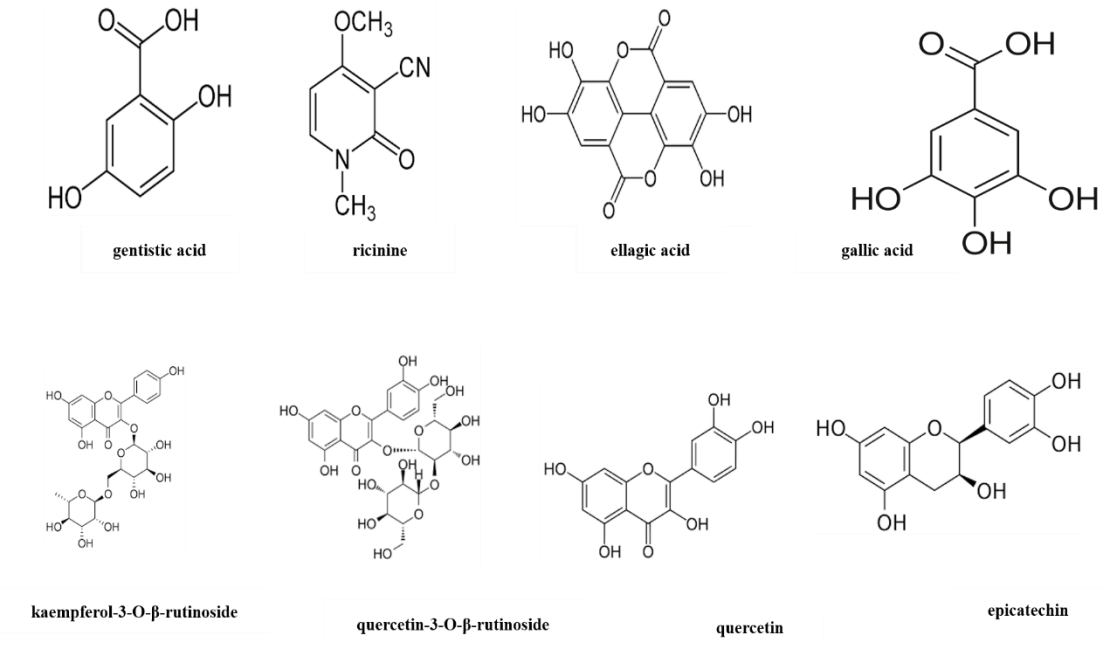

Fig. 4. Chemical structures of some bioactive components in *Ricins communis*.

It is worth that previous studies attributed the biological effects of castor as a result of the active compounds such as ellagic acid, gallic acid, quercetin, epicatechin, gentisic acid, rutin and

alkaloids; ricinine (0.55%) and N demethylricinine (0.016%)] and flavones; glycosides kaempferol-3-O-β-D-Xylopyranoside, kaempferol-3-O-β-D-glucopyranoside, quercetin-3-O-β-D-xylopyranoside, quercetin-3-O-β-D-glucopyranoside, kaempferol-3-O-β-rutinoside and quercetin-3-O-β-rutinoside (Kang et al., 1985; Singh et al., 2009 Nath et al., 2011; Rana et al., 2012), and tannins (Sibi et al., 2012). As well as, monoterpenoids (1, 8-cineole, camphor and α-pinene), sesquiterpenoid (β-caryophyllene), and phenolic compounds include, gallic acid, quercetin, gentisic acid, rutin, epicatechin and ellagic acid. Indole-3-acetic acid has been extracted from the roots (Darmanin et al., 2009 and Singh et al., 2009, 12). Figure 5. Shows the health benefits of *Ricinus communis*.

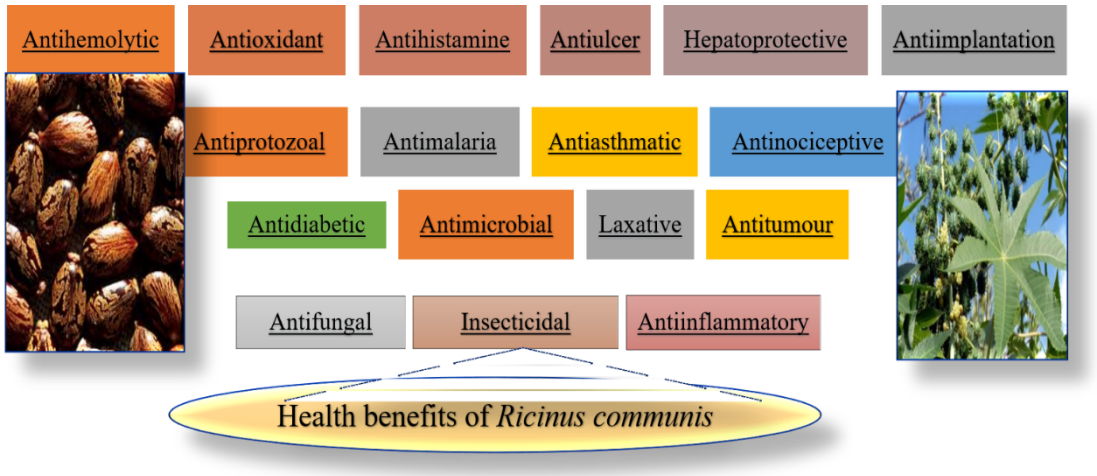

Figure 5. Health benefits of *Ricinus communis*.

3. Pharmacological applications

From the results of previous studies, which showed the use of *R. communis* in the treatment of hepatitis, skin and breast cancer (Rana et al., 2012; Gupta et al., 2004; Shukla et al., 1992; Visen et al., 1992), antidiabetic (Shokeen et al., 2008; Abbas et al., 2018) and antioxidant due to phenolic and flavonoid compounds (Iqbal et al., 2012; Surveswaran et al., 2007) as well as antifeedant and toxic effects i.e., abrin and ricin; leaf extracts of *R. communis* had effects against pest (Kodjo et al., 2011; Olsnes et al., 1975; Aslani et al., 2007; Devanand and Rani, 2008). Besides being insecticidal (Upasani et al., 2003), contraceptive (Okwuasaba et al., 1997) and antifertility activity (Sandhyakumary et al., 2003), antimalaria, insecticidal, antioxidant, anti-implantation, antiinflammatory, antidiabetic, antitumour, larvicidal, anti-microbial and anti-fungal, antinociceptive and antiasthmatic activity were biological activities as mentioned by (Berman et al., 2011; Junior et al., 2011; Kang et al., 1985; Darmanin et al., 2009; Singh et al., 2009; Khogali et al., 1992; Ochora et al., 2014; Basheer, 2014; Lomash et al., 2010).

El-Naggar (2019) showed that the ricinine alkaloid in *Ricinus communis* and its derivatives have antimicrobial activity against *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeuroginosa*, *Staphylococcus aureus*, and *Candida albicans*. Antioxidant, antihemolytic and antibacterial activities of *Ricinus communis* was also endorsed by Alugah and Ibraheem (2014), due to its content of flavonoids and tannins in the various parts (leaves, stems, roots, capsules and seeds). Previous research supported the active role of *Ricinus communis* as antioxidant, antimicrobial, antihelmintic, laxative, diuretic, insecticidal, anti-inflammatory, hypoglycemia treatment, headache, edema, dermatitis, ringworm, rheumatism, asthma, warts,

dandruff (Jena et al., 2012; Obumselu et al., 2011; Nath et al., 2011; Rana et al., 2012; Sibi et al., 2012; Friedman et al., 2013).

Studies on *R. communis* seeds have confirmed its effectiveness an anti-fertility effect as decreasing testosterone, reproductive organs weight, sperm functions and disruption of seminiferous tubules and erosion of the germinal epithelium in male rats (Nath et al., 2011; Raji et al., 2006), and reduction of progesterone, altering the oestrogen/progesterone balance, and abortifacient effect on the uterus and fallopian tube (Nath et al., 2011; Okwuasaba et al., 1997). As appeared as in the study of Bhakta and Das (2015) being an antiimplantation, anticancer, antioxidant, antifertility, antinociceptive, in vitro immunomodulatory, hepatoprotective, antidiabetic, antiulcer, antimicrobial and antifungal, insecticidal, bone regeneration, central anagesic, antihistaminic, antiasthmatic, molluscicidal and larvicidal, lipolytic, antiinflammatory and wound healing, due to the steroids, saponins, alkaloids, flavonoids, and glycosides contents.

Haque et al., (2020) revealed that *Ricinus communis* (leaf, twig, bark, stem, root, precarp and seed) extracts have allelopathic properties. (Taur et al., 2011) said that, Ricinus communis leaves contains of alkaloids, saponin and steroids and have antinociceptive activity. Leaf, root and seed oil have been used for the treatment of inflammation and liver disorders (Kirtikar and Basu, 1985). It is reported that this plant possesses hepatoprotective (Yanfg et al., 1987; Visen et al., 1992), antidiabetic (Shokeen et al., 2008), laxative (Capasso et al., 1994), and antifertility activities (Sandhyakumary et al., 2003). Root extract shows anti-inflammatory and free radical scavenging activity (Ilavarasan et al., 2006). Moreover, quercetin, ellagic acid, gallic acid, gentisic acid, rutin and epicatechin are possessing antioxidant activity (Singh et al., 2009).

4. Essential oil

Kadri et al. (2011) showed that, α-thujone (31.71%), 1,8-cineole (30.98%), α-pinene (16.88%), camphor (12.98%) and camphene (7.48%) were the major compounds in *Ricinus communis* leaves essential oil, which has anticarcinogenic and antimicrobial properties as well as repellent potential and insecticidal effect against *Tribolium castaneum* and *Lasioderma serricorne* (Salem et al., 2017). They added that, 2,4-bis (dimethylbenzyl)-6-t-butylphenol was the main volatile compound of castor essential oil. *Ricinus communis* oil is also used as anticancer, insecticidal, antidiabetic, larvicidal, antiprotozoal, and adult emergence inhibition activities (Manpreet et al., 2012), and ricin is used in phytotherapy and traditional medicine (Bum et al., 2011). Figure 6. shows the chemical structures of some essential oil components identified from *Ricinus communis*.

5. Oil seed

Studies on R. communis seeds concluded that seeds are a source of protein and oil. The oil yield in the seeds is about 50%. The oil has medicinal activities and various applications such as coating materials, print ink, resin materials and cosmetics. However, presence of ricin and agglutinin is a major problem for using *R. communis* oil in nutritional applications (Ahmad, 2017). The fatty acid profiles of castor oil are oleic, stearic, palmitic, linoleic, linolenic acid, and ricinoleic acid is a monounsaturated fatty acid dominant acid represents about 75 to 90% of the total oil composition (Beruk et al., 2018; Panhwar et al., 2016; Yusuf et al., 2015). Also, the fatty acid profile of castor has low amount of saturated and polyunsaturated fatty acids and this enhance its stability (Yusuf et al., 2015), so castor oil shares a higher similarity with that of macadamia nut, palm kernel, olive, and sunflower oil (Nor Hayati et al., 2009; Sinanoglou et al., 2014), and those nutritional unsaturated acids play an important role in reducing individual risks associated with asthma, cardiovascular diseases, cancer, and diabetes (Ganesan et al., 2018).

Castor oil has high nutritional value owing to its rich amount of monounsaturated fatty acid and bioactive active antioxidants compounds such as vitamin E component (tocopherols or tocotrienols), phospholipids and phenolic compounds (Sedeek et al., 2012; Said et al., 2016). As the tocopherols are one of the natural antioxidants in castor oil with anti-proliferative and anti-inflammatory properties (Said et al., 2016; Sbihi et al., 2018).

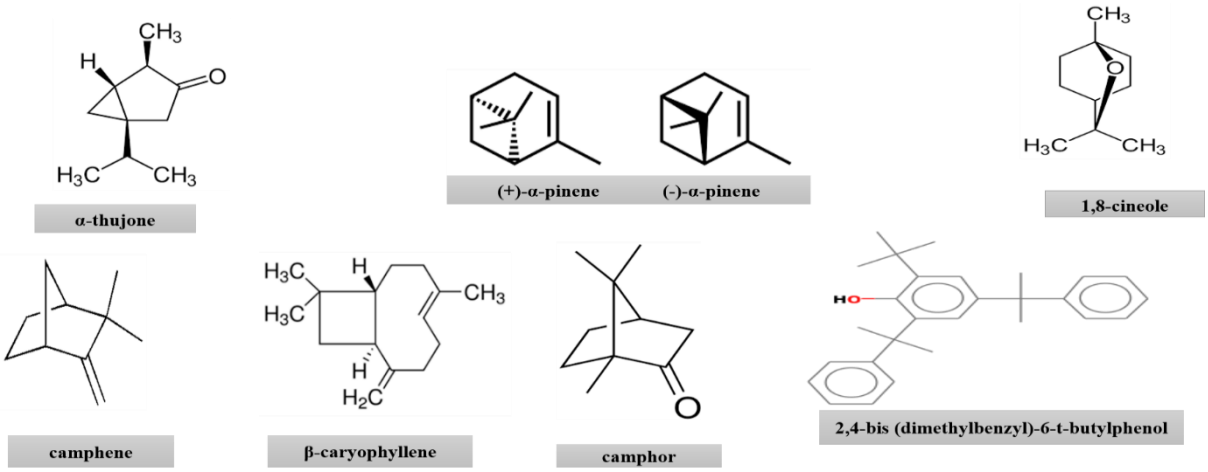

Fig 6. Chemical structures of some essential oil components

6. Conclusion

In this review, the medicinal properties of *Ricinus communis* were examined to confirm its therapeutic importance. *R. communis* is an important medicinal plant with potential effect on ulcers, microorganisms, bacteria, insects, and other parasites that affect health and immunity. Based on the above literature, it may conclude that the disease prevention and recurring characteristic of the *Ricinus communis* made this plant highly noticeable which provides many alternatives solutions in medical areas, and several fields such as agriculture, pharmacy, economic, industry and others. The pharmacological activities shown by the Ricinus communis have supported the traditional use of this herb as a medicinal plant and creating the source for sustainable synthetic drugs. As a result of its content of biologically active compounds that allow a good future in the medical world and have built opportunities for further investigation to find the new compounds of *Ricinus communis*.

7. References

Abbas, M., Ali, A., Arshad, M., Atta, A., Mehmood, Z., Tahir, I.M. et al. (2018). Mutagenicity, cytotoxic and antioxidant activities of *Ricinus communis* different parts. Chem Cent J., 12(1):3.

Abdul, W.M., Hajrah, N.H., Sabir, J.S.M., Al-Garni, S.M., Sabir, M.J., Kabli, S.A. et al. (2018). Therapeutic role of *Ricinus communis* L. and its bioactive compounds in disease prevention and treatment. Asian Pac J Trop Med., 11(3):177-85.

Accioly, M.P., Bevilaqua, C.M., Rondon, F.C., de Morais, S.M., Machado, L.K., Almeida, C.A. et al. (2012). Leishmanicidal activity in vitro of *Musa paradisiaca* L. and *Spondias mombin* L. fractions. Vet Parasitol., 187(1-2):79-84.

Adaramola. B., Onigbinde. A., Shokunbi, O. (2016). Physiochemical properties and antioxidant potential of *Persea americana* seed oil. Chem Int., 2(3):168-175.

Adekunle, A.E. (2011). Larvicidal and insecticidal properties of *Ricinus communis* seed extracts obtained by different methods against *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae). Archives of Phytopathology and Plant Protection. 44 (5): 451-459.

Ahmad, P. (2017). Oilseed Crops: Yield and Adaptations under environmental stress. Saadaoui E., Martín JJ., Tlili N., Cervantes E., Chapter 2: Castor bean (*Ricinus communis* L.) diversity, seed oil and uses. Print ISBN:9781119048770 |Online ISBN:9781119048800, |DOI:10.1002/9781119048800 © 2017 John Wiley & Sons Ltd.

Alugah, C.I., Ibraheem, O. (2014). Whole plant screenings for flavonoids and tannins contents in castor plant (*Ricinus communis* L.) and evaluation of their biological activities. International Journal of Herbal Medicine. 2 (2): 68-76.

Ani, A.O. (2007). Effects of graded levels of dehulled and cooked castor oil bean (*Ricinus communis* L.) meal and supplementary L-lysine on performance of broiler finishers. J. Trop. Agric. Food Environ. Ext., 6: 89-97.

Anjani, K. (2014). A re-evaluation of castor (*Ricinus communis* L.) as a crop plant. Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources. 9(1): 1-21.

Anthony, J.P., Fyfe, L., Smith, H. (2005). Plant active components-a resource for antiparasitic agents? Trends Parasitol., 21(10):462-8.

Aqil, M., Khan, I.Z., Otukoyoung, E.E. (1997). Three flavonol glycosides from Ricinus communis. Bull.Chem.Soc.Ethiop., 11(1):51-53.

Aslani, M.R., Maleki, M., Mohri, M., Sharifi, K., Najjar-Nezhad, V., Afshari, E. (2007). Castor bean (*Ricinus communis*) toxicosis in a sheep flock. Toxicon. 49(3):400-406.

Bahmani, M., Saki, K., Ezatpour, B., Shahsavari, S., Eftekhari, Z., Jelodari, M. et al. (2015). Leishmaniosis phytotherapy: Review of plants used in Iranian traditional medicine on leishmaniasis. Asian Pac J Trop Biomed., 5(9): 695-701.

Basheer, A.G.M. (2014). Ricinus communis (CASTOR) as larvicide on *Anopheles arabiensis* Patton. International Journal of advances in Pharmacy, Biology and Chemistry, 3(2): 319-328.

Berman, P., Nizri, S., Wiesman, Z. (2011). Castor oil biodiesel and its blends as alternative fuel. Biomass Bioenerg., 35: 2861-2866.

Beruk, A.B., Abel, W.O., Assefa, A.T., Sintayehu, S.H. (2018). Studies on Ethiopian castor seed (*Ricinus communis* L.): extraction and characterization of seed oil. Journal of Natural Production Resource, 4(2): 188-190.

Bhakta, S., Das, S.K. (2015). In praise of the medicinal plant *Ricinus communis* L.: A review. Global J Res. Med. Plants & Indigen. Med.,4 (5):95-105.

Bum, E.N., Taiwe, G.S., Moto, F.C.O., Ngoupaye, G.T., Vougat, R.R.N., Sakoue, V.D. et al. (2011). Antiepileptic medicinal plants used in traditional medicine to treat epilepsy. In Clinical and genetic aspects of epilepsy; Zaid Afawi, ed., In Tech, ISBN 978-953-307-700-0, 175-192.

Capasso, F., Mascolo, N., Izzo, A.A., Gaginella, T.S. (1994). Dissociation of castor oil induced diarrhoea and intestinal mucosal injury in rat: effect of NG-nitro-l-arginine methyl ester. Br J Pharmacol., 113: 1127-1130.

Carneiro, S.M., Carvalho, F.A., Santana, L.C., Sousa, A.P.., Neto, J.M., Chaves, M.H. (2012). The cytotoxic and antileishmanial activity of extracts and fractions of leaves and fruits of *Azadirachta indica* (A Juss.). Biol Res., 45:111–6.

Centers for Disease Control and Prevention (CDC). 2020. Global Health, Division of Parasitic Diseases and Malaria. Accessed February 14, 2020.

Chouhan, H.S., Swarnakar, G., Jogpal, B. (2021). Medicinal properties of *Ricinus communis*: A review. International Journal of Pharmaceutical Sciences and Research. 12(7): 3632-3642.

Corral, M.J., Benito-Pena, E., Jimenez-Anton, M.D., Cuevas, L., Moreno-Bondi, M.C., Alunda, J.M. (2016). Allicin induces calcium and mitochondrial dysregulation causing necrotic death in Leishmania. PLoS Negl Trop Dis., 10(3). e0004525.

Darmanin, S., Wismaver, P.S., Camillerri Podesta, M.T., Micallef, M.J., Buhagiar, J.A. (2009). An extract from *Ricinus communis* L. leaves possesses cytotoxic properties and induces apoptosis in SKMEL- 28 human melanoma cells. Nat Prod Res., 23(6): 561-571.

Date, A.A., Joshi, M.D., Patravale, V.B. (2007). Parasitic diseases: Liposomes and polymeric nanoparticles versus lipid nanoparticles. Adv Drug Deliv Rev., 59(6):505-21.

Dayakar, A., Chandrasekaran, S., Veronica, J., Sundar, S., Maurya, R. (2015). In vitro and in vivo evaluation of anti-leishmanial and immunomodulatory activity of Neem leaf extract in *Leishmania donovani* infection. Exp Parasitol.,153:45-54.

Devanand, P., Rani, P.U. (2008). Biological potency of certain plant extracts in management of two lepidopteran pests of *Ricinus communis* L. J Biopest., 1(2):170-176.

Dinesh, D.S., Kumari, S., Kumar, V., Das, P. (2014). The potentiality of botanicals and their products as an alternative to chemical insecticides to sandflies (Diptera: Psychodidae): a review. J Vector Borne Dis.,51(1):1-7.

Diniz, L.L., Valadares Filho, S.C., de Oliveira, A.S., Pina, D.S., de Lima da Silva, N., Benedeti, P.B. et al. (2011). Castor bean meal for cattle finishing: 1–nutritional parameters. Livest. Sci., 135: 153-167.

El-Naggar, M.H., Elgaml, A., Abdel Bar, F.M., Badria, F.A. (2019). Antimicrobial and antiquorum-sensing activity of *Ricinus communis* extracts and ricinine derivatives. Natural Product Research Formerly Natural Product Letters. 33 (11): 1556-1562.

Fokou, P.V.T., Kissi-Twum, A.A., Yeboah-Manu, D., Appiah-Opong, R., Addo, P., Tchokouaha Yamthe, L.R. et al. (2016). In vitro activity of selected West African medicinal plants against *Mycobacterium ulcerans* disease. Molecules. 21(4):445.

Friedman, M.H., Andreu, M.G., Quintana, H.V., McKenzie, M. (2013). *Ricinus communis*, castor Bean, University of Florida. P.1-2.

Ganesan, K., Sukalingam, K., & Xu, B. (2018). Impact of consumption and cooking manners of vegetable oils on cardiovascular diseases-A critical review. Trends in Food Science & Technology. 71: 132-154.

Ghosh, S., Tiwari, S.S., Srivastava, S., Sharma, A.K., Kumar, S., Ray, D.D. et al. (2013). Acaricidal properties of *Ricinus communis* leaf extracts against organophosphate and pyrethroids resistant *Rhipicephalus* (Boophilus) *microplus*. Vet Parasitol., 192(1-3): 259-267.

Gowda, N.K.S., Pal, D.T., Bellur, S.R., Bharadwaj, U., Sridhar, M., Satyanarayana, M.L. et al. (2009). Evaluation of castor (*Ricinus communis*) seed cake in the total mixed ration for sheep. J. Sci. Food Agric., 89, 216-220.

Gupta, R.S., Bhatnager, A.K., Joshi, Y.C., Sharma, R., Sharma, A. (2004). Effects of plumieride, an iridoid on spermatogenesis in male albino rats. Phytomedicine. 11(2-3):169-74.

Hamid, A.A., Oguntoye, S.O., Alli, S.O., Akomolafe, G.A., Aderinto, A., Otitigbe, A. et al. (2016). Chemical composition, antimicrobial and free radical scavenging activities of *Grewia pubescens*. Chem Int., 2(4):254-261.

Haque, Md.M., Mominul Islam, A.K.M., Anwar, Md.P., Yeasmin, S. (2020). Evaluation of allelopathic potential of *Ricinus communis* on the growth of seven field crops. Research Journal of Medicinal Plants. 14:79-87.

Hikal, W.M., Said-Al Ahl, H.A.H. (2019 a). Cysticidal activity of *Trachyspermum ammi* essential oil against *Acanthamoeba* isolates from dental clinic and hospital water networks. Pakistan J. Zool., 51(5): 1799-1806.

Hikal, WM., Said-Al Ahl, H.A.H. (2019 b). Influence of *Plectranthus amboinicus* essential oil on potentially pathogenic *Acanthamoeba* isolated from water tanks in Tabuk, Saudi Arabia. Eco Env & Cons., 25 (3): 1137-1145.

Hikal, W.M., Baeshen, R.S., Said-Al Ahl, H.A.H. (2017). Botanical insecticide as simple extractives for pest control. Cogent Biology. 4: 1404274.

Hikal, W.M., Said-Al Ahl, H.A.H., Tkachenko, K.G. (2020). Present and future potential of antiparasitic activity of *Opuntia ficus-indica*. Trop J Nat Prod Res., 4(10):672-679.

Hikal, W.M., Tkachenko, K.G., Said-Al Ahl, H.A.H., Sany, H., Sabra, A.S., Baeshen, R.S., Bratovcic, A. (2021). Chemical composition and biological significance of thymol as antiparasitic. Open Journal of Ecology. 11, 240-266.

Hikal,W.M., Said-Al Ahl, H.A.H. (2017). Anti-leishmanial activity of *Hyssopus officinalis*: A review. International Journal of Environmental Planning and Management. 3 (2): 10-15.

Houbairi, S., Elmiziani, I., Lamiri, A., Essahli, M. (2015). Comparison of the antioxidant activity of aromatic medicinal plants of Moroccan origin. Eur J Med Plants. 10(4): 1-10.

Ilavarasan, R., Mallika, M., Venkataraman, S. (2006). Anti-inflammatory and free radical scavenging activity of *Ricinus communis* root extract. J Ethnopharmacol., 103: 478-480.

Iqbal, J., Zaib, S., Farooq, U., Khan, A., Bibi, I., Suleman, S. (2012). Antioxidant, antimicrobial, and free radical scavenging potential of aerial parts of *Periploca aphylla* and *Ricinus communis*. ISRN Pharmacol., 2012:1-6.

Jacobson R.L., Schlein Y. (1999). Lectins and toxins in the plant diet of *Phlebotomus papatasi* (Diptera: Psychodidae) can kill *Leishmania major* promastigotes in the sandfly and in culture. Ann Trop Med Parasitol., 93(4):351-6.

Jena, J., Gupta, A.K. (2012). *Ricinus communis* Linn: A Phytopharmacological review. International Journal of Pharmacy and Pharmaceutical Sciences. 4 (4): 25-28

Jeyam, M, Arangaraj, M, Ravikumar, P, Shalini, G. (2014). Computational analysis of phytocompounds with 1,3- β -D-glucan synthase for antidermatophytic activity. Sci Rep., 6: 24027.

Jumba, B.N., Anjili, C.O., Makwali, J., Ingonga, J., Nyamao, R., Marango, S. et al. (2015). Evaluation of leishmanicidal activity and cytotoxicity of *Ricinus communis* and *Azadirachta indica* extracts from western Kenya: in vitro and in vivo assays. BMC Res Notes. 8:650.

Junior, E.M., Fernandez, I.M., Santos, C.S., de Mesquita, L.X., Pereira, R.A., Maracaja, P.B. et al. (2011). Toxicity of castor bean (*Ricinus communis*) pollen to honeybees Agriculture, Ecosystems and Environment. 141: 221-223.

Kadri, A., Gharsallah, N., Damak, M., Gdoura, R. (2011). Chemical composition and in vitro antioxidant properties of essential oil of *Ricinus communis* L. Journal of Medicinal Plants Research. 5(8): 1466-1470.

Kang, S.S., Cordell, A., Soejarto, D.D., Fong, H.H.S. (1985). Alkaloids and flavonoids from *Ricinus communis*. J. Nat. Prod., 48 (1): 155-156.

Khafagy, S.M., Mahmoud, Z.F., Salam, N.A.E. (1979). Coumarins and flavanoids of *Ricinus communis* growing in Egypt. Planta Medica. 37: 191.

Khogali, A., Barakat, S., Abou-Zeid, H. (1992). Isolation and identification of the phenolics from *Ricinus communis* L. Delta J. Sci., 16: 198-211.

Kirtikar, K.R., Basu, B.D. (1985). Indian medicinal plants. 2nd ed. Dehradun: International Book Distributor; p. 2274-2277.

Kodjo, T.A., Gbénonchi, M., Sadate, A., Komi., A., Yaovi, G., Dieudonné, M. et al. (2011). Bio insecticidal effects of plant extracts and oil emulsions of *Ricinus communis* L. (Malpighiales: Euphorbiaceae) on the diamondback, *Plutella xylostella* L. (Lepidoptera: Plutellidae) under laboratory and semifield conditions. J Appl Biosci., 43:2899-2914.

Lima, R.L.S., Severino, L.S., Sampaio, L.R., Sofiatti, V., Gomes, J.A., Beltrão, N.E.M. (2011). Blends of castor meal and castor husks for optimized use as organic fertilizer. Ind. Crops Prod., 33, 364–368.

Lomash, V., Parihar, S.K., Jain, N.K., Katiyar, A.K. (2010). Effect of *Solanum nigrum* and *Ricinus communis* extracts on histamine and carrageenan-induced inflammation in the chicken skin. Cell Mol Biol (Noisy-le-grand). 56(Suppl): OL1239-51.

Manpreet, R.; Dhamija, H.; Prashar, B.; Sharma, S. (2012). *Ricinus communis* L.-A Review. Int. J. Pharm.Tech. Res., 4 (4): 1706-1711.

Moreira, D.L., Teixeira, S.S., Monteiro, M.H.D., De-Oliveira, A.C.A.X., Paumgartten, F.J.R. (2014). Traditional use and safety of herbal medicines. Rev Bras Farmacogn., 24(2): 248-257.

Nath, S, Choudhury, MD, Roychoudhury, S, Talukdar, AD, Sirotkin, AV, Bakova, Z. et al. (2011). Restorative aspect of castor plant on mammalian physiology: A review. Journal of Microbiology, Biotechnology and Food Sciences. 1 (2): 236-243.

Ngo, T, Nguyen, T, Bui D, Hoang, N, Nguyen, T. (2016). Effects of ricin extracted from seeds of the castor bean (*Ricinus communis*) on cytotoxicity and tumorigenesis of melanoma cells. Biomed Res Ther., 3(5): 633-644.

Nor Hayati, I., Che Man, Y. B., Tan, C. P., Nor Aini, I. (2009). Physicochemical characteristics of soybean oil, palm kernel olein, and their binary blends. International Journal of Food Science & Technology. 44(1): 152-161.

Obumselu, F.O., Okerulu, I.O., Onwukeme, V.I., Onuegbu, T.U., Eze, R.C. (2011). Phytochemical and antibacterial analysis of the leaf extracts of *Ricinus communis*. Journal of Basic Physical Research. 2 (2): 68-69.

Ochora, D.O., Fidahusein, D.S., Nguta, J.M., Akunda, E.M. (2014). Antimalarial activity and acute toxicity of four plants traditionally used in treatment of malaria in Msambweni District of Kenya. European International Journal of Science and Technology. 3 (7): 31-40.

Okech, B.G.A., Irungu, L.W., Anjili, C.O., Munyua, J.K., Njagi, E.N.M., & Rukungu, G. (2006). In vitro activity of total aqueous ethanol leaf extracts of *Ricinus communis* on *Leishmania major* promastigotes. Kenya Journal of Science and Technology Series B, Biological Sciences. 13(1):1-4.

Okwuasaba, F.K., Das, S.C., Isichei, C.O., Ekwenchi, M.M., Onoruvwe O., Olayinka, A.O. et al. (1997). Pharmacological studies on the antifertility effects of RICOM-1013-J from *Ricinus communis* var minor and preliminary clinical studies on women volunteers. Phytotherapy Research. 11 (8): 547-551.

Okwuasaba, F. K., Das, S.C., Isichei, C.O., Ekwenchi, M. M., Onoruvwe, O., Olayinka, A.O., et al. (1997). The anticonceptive and the effect on uterus of ether extract, 18312-J of *Ricinus communis*. Phytotherapy Research. 10: 97-100.

Olsnes, S., Refsnes, K., Christensen, T.B., Pihl A. (1975). Studies on the structure and properties of the lectins from *Abrus precatorius* and *Ricinus communis*. Biochim Biophys Acta-Protein Struct., 405(1):1-10.

Oyeewole, O.I., Owoseni, A.A., Faboro, E.O. (2010). Studies on medicinal and toxicological properties of *Cajanus cajan*, *R. communis* and *Thymus vulgaris* leaf extracts. J Med Plant Res., 4:2004-8.

Panhwar, T., Mahesar, S.A., Mahesar, A.W., Kandhro, A.A., Talpur, F.N., Laghari, Z.H. et al. (2016). Characteristics and composition of a high oil yielding castor variety from Pakistan. Journal of Oleo Science. 65(6): 471-476.

Parkouda, C., Nielsen, D.S., Azokpota, P., Ouoba, L.I.I., Amoa-Awua, W.K., Thorsen, L. et al. (2009). The microbiology of alkaline-fermentation of indigenous seeds used as food condiments in Africa and Asia. Crit. Rev. Microbiol., 35: 139-156.

Raji, Y., Oloyo, A.K., Morakinyo, A.O. (20060. Complementary medicine: Effect of methanol extracts of *Ricinus communis* seed on reproduction of male rats. Asian Journal of Andrology. 8 (1):115-121.

Rana, M., Dhamija, H., Prashar, B., Sharma, S. (2012). *Ricinus communis* L.-a review. Int J PharmTech Res., 4(4):1706-1711.

Rinner, U. (2015). Progress in the preparation of jatrophane diterpenes. Eur J Org Chem., 15: 3197-3219.

Rondon, F.C.M., Bevilaqua, C.M.L., Accioly, M.P., Morais, S.M., Andrade-Junior, H.F., Machado, L.K. et al. (2011). In vitro effect of *Aloe vera*, *Coriandrum sativum* and *Ricinus communis* fractions on *Leishmania infantum* and on murine monocytic cells. Vet Parasitol., 178(3-4): 235-240.

Sadeghian, G., Ziaei, H., Sadeghi, M. (2008). Electrocardiographic changes in patients with cutaneous leishmaniasis treated with systemic glucantime. Ann Acad Med Singap., 37(11):916-8.

Said, G., Daniel, P., Badr, K., Mohamed, I., Zoubida, C. (2016). Chemical characterization and oxidative stability of castor oil grown in Morocco. Moroccan Journal of Chemistry. 4(2): 279-284.

Said-Al Ahl, H.A.H., Hikal, W.M., Mahmoud, A.A. (2017). Essential Oils: Biosynthesis, chemistry and biological functions. Journal of Chemical and Pharmaceutical Research. 9(8):190-200.

Salem, N., Bachrouch, O., Sriti, J, Msaada, K, Khammassi, S., Hammami, M., Selmi, S., Boushih, E., Koorani, S., Abderraba, M., Marzouk, B., Limam, F., Ben Jemaa, J.M. (2017). Fumigant and repellent potentials of *Ricinus communis* and *Mentha pulegium* essential oils against *Tribolium castaneum* and *Lasioderma serricorne*, International Journal of Food Properties. 20:sup3: S2899-S2913.

Samad, M.A., Hashim, S.H., Simarani, K., Yaacob, J.S. (2016). Antibacterial properties and effects of fruit chilling and extract storage on antioxidant activity, total phenolic and anthocyanin content of four date palm (*Phoenix dactylifera*) cultivars. Molecules. 21(4):419.

Sandhyakumary, K., Bobby, R. G., Indira, M. (2003). Antifertility effects of *Ricinus communis* (Linn) on rats. Phytotherapy Research. 17: 508-511.

Sbihi, H.M., Nehdi, I.A., Mokbli, S., Romdhani-Younes, M., Al-Resayes, S.I. (2018). Hexane and ethanol extracted seed oils and leaf essential compositions from two castor plant (*Ricinus communis* L.) varieties. Industrial Crops and Products. 122: 174-181.

Schlein, Y., Jacobson, R.L., Muller, G.C. (2001). Sand fly feeding on noxious plants: a potential method for the control of leishmaniasis. Am J Trop Med Hyg., 65(4):300-3.

Sedeek, S., El-Ghobashy, R., Tawfik, M. (2012). Thermal stability of cottonseed oil mixed with jojoba or castor oil during frying process. Journal of Biological Chemistry and Environmental Science. 7(2): 39-56.

Shokeen, P., Anand, P., Murali, Y.K., Tandon, V. (2008). Antidiabetic activity of 50% ethanolic extract of *Ricinus communis* and its purified fractions. Food Chem Toxicol., 46(11):3458-3466.

Shukla, B., Visen, P.K.S., Patnaik, G.K., Kapoor, N.K., Dhawan, B.N. (1992). Hepatoprotective effect of an active constituent isolated from the leaves of *Ricinus communis* Linn. Drug Development Research. 26: 183-193.

Sibi, G., Gurmeetkaur, Devi G., Dhananjaya, K., Ravikumar, K.R., Mallesha, H. (2012). Anti-dandruff activity of *Ricinus communis* L. leaf extracts. International Journal of Current Pharmaceutical Research. 4 (3): 74-76.

Sinanoglou, V.J., Kokkotou, K., Fotakis, C., Strati, I., Proestos, C., Zoumpoulakis, P. (2014). Monitoring the quality of γ-irradiated macadamia nuts based on lipid profile analysis and Chemometrics. Traceability models of irradiated samples. Food Research International. 60: 38-47.

Singh, P.P., Ambika Chauhan, S.M.S. (2009). Activity guided isolation of antioxidants from the leaves of *Ricinus communis* L. Food Chem., 114(3): 1069-1072.

Soosaraei, M., Fakhar, M., Hosseini Teshnizi, S., Ziaei Hezarjaribi, H., Banimostafavi, E.S. (2017). Medicinal plants with promising antileishmanial activity in Iran: a systematic review and meta-analysis. Ann Med Surg (Lond). 21:63-80.

Surveswaran, S., Cai, Y.Z., Corke, H., Sun, M. (2007). Systematic evaluation of natural phenolic antioxidants from 133 Indian medicinal plants. Food Chem., 102(3):938-953.

Taur, D.J., Waghmare, M.G., Bandal, R.S., Patil, R.Y. (2011). Antinociceptive activity of *Ricinus communis* L. leaves. Asian Pacific Journal of Tropical Biomedicine. 1(2): 139-141.

Thomford, N.E., Awortwe, C., Dzobo, K., Adu, F., Chopera, D., Wonkam, A. et al. (2016). Inhibition of CYP2B6 by medicinal plant extracts: implication for use of efavirenz and nevirapine-based highly active anti-retroviral therapy (HAART) in resource-limited settings. Molecules. 21(2):211.

Upasani, S. M., Kotkar, H. M., Mendki, P. S., Maheshwari, V.L. (2003). Partial characterization and insecticidal properties of *Ricinus communis* L. foliage flavonoids. Pest Management Science. 59: 1349-1354.

Vermeer, C.P., Nastold, P., Jetter, R. (2003). Homologous very-long-chain 1,3- alkanediols and 3-hydroxyaldehydes in leaf cuticular waxes of *Ricinus communis* L. Phytochem., 62(3): 433-438.

Visen, P.K.S., Shukla, B., Patnaik, G.K., Tripathi, S.C., Kulshreshtha, D.K., Srimal, R.C., et al. (1992). Hepatoprotective activity of *Ricinus communis* leaves. International Journal of Pharmacognosy. 30: 241-250.

Worbs, S., Köhler, K., Pauly, D., Avondet, M., Schaer, M., Dorner, M.B. Dorner, B.G. (2011). *Ricinus communis* intoxications in human and veterinary medicine- A summary of real cases. Toxins. 3: 1332-1372.

World Health Organization (WHO). 2021. Leishmaniasi; WHO Press: Geneva, Switzerland, 2020.

Yanfg, L.L., Yen, K.Y., Kiso, Y., Kikino, H. (1987). Antihepatotoxic actions of formosan plant drugs. J Ethanopharmacol., 19: 103-110.

Yeboah, A., Ying, S., LU, J., Xie, Y., Amoanimaa-Dede, H., Boateng, KGA., Chen, M., Yin, X. (2020). Castor oil (*Ricinus communis*): a review on the chemical composition and physicochemical properties. Food Sci. Technol, Campinas, Ahead of Print, 2020.

Ying, S., Hill, A. T., Pyc, M., Anderson, E. M., Snedden, W. A., Mullen, R. T. et al. (2017). Regulatory phosphorylation of bacterial-type PEP carboxylase by the Ca2+-dependent protein kinase RcCDPK1 in developing castor oil seeds. Plant Physiology. 174(2): 1012-1027.

Yusuf, A., Mamza, P., Ahmed, A., & Agunwa, U. (2015). Extraction and characterization of castor seed oil from wild *Ricinus communis* Linn. International Journal of Science, Environment and Technology. 4(5): 1392-1404.

Zahir A.A., Rahuman A.A., Bagavan A., Geetha K., Kamaraj C., Elango G. (2011). Evaluation of medicinal plant extracts and isolated compound epicatechin from *Ricinus communis* against *Paramphistomum cervi*. Parasitol Res., 111(4): 1629-1635.

Zahir, A.A., Rahuman, A.A., Bagavan, A., Santhoshkumar, T., Mohamed, R.R., Kamaraj, C. et al. (2010). Evaluation of botanical extracts against *Haemaphysalis bispinosa* Neumann and *Hippobosca maculata* Leach. Parasitol Res., 107(3):585-592.

Zahir, AA., AbdulRahuman, A., Pakrashi, S., Ghosh, D., Bagavan, A., Kamaraj, C. et al. (2012). Evaluation of antileishmanial activity of South Indian medicinal plants against *Leishmania donovani*. Experimental Parasitology.132 (2):180-184.

Zarai, Z., Chobba, I.B., Mansour, R.B., Békir, A, Gharsallah, N., Kadri, A. (2012). Essential oil of the leaves of *Ricinus communis* L.: In vitro cytotoxicity and antimicrobial properties. Lipids Health Dis., 11: 102.

Zarandi, H.Z., Shirani-Bidabadi, L., Aghaei-Afshar, A., Eghbalian, M., Zolala, J., Mir-Tadjedini, S.M. et al. (2021). In vitro evaluation of hydroalcoholic extracts of *Capparis spinosa* L., *Ricinus communis*, and *Solanum luteum* on *Leishmania major* (MRHO/IR/75/ER) promastigotes. Jundishapur J Nat Pharm Prod., e115306.