The Chemical Compounds of *Retama monosperma*

Subjects: Integrative & Complementary Medicine

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Retama monosperma L. (Boiss.) or *Genista monosperma* L. (Lam.), known locally as “R’tam”, is a spontaneous and annual herb that belongs to the Fabaceae family. It is native to the Mediterranean regions, specifically in the desert areas and across the Middle Atlas in Morocco. This plant has been extensively used in folk medicine and it is rich in bioactive compounds, including polyphenols, flavonoids, and alkaloids.

Keywords: Retama monosperma L. ; medicinal plant ; extract

1. Introduction

Retama monosperma L. (Boiss.) or *Genista monosperma* L. (Lam.), known locally in the popular Arabic name as “R’tam” [1], is a spontaneous, abundant, and annual herb that belongs to the family of Fabaceae. It is endemic to the west of the Mediterranean basin, such as the Canary Islands, Portugal, Italy, southwest Spain, Macaronesia, North Africa, and northern Egypt [2]. In Morocco, it is situated in the desert areas and across the Middle Atlas and in several Moroccan natural forests [3]. It has a large geographic distribution and represents a potential for use in the stability of dunes and the revegetation of desert ecosystems, and is occasionally cultivated as an ornamental herb, especially in Mediterranean climates [4]. For many years, plants have been used by humans for medicinal and nutritional purposes in the food industry and other applications [5][6][7][8]. In recent decades, they have drawn significant interest and represent a largely untapped source of novel and effective drugs to overcome resistance to the treatment of a wide spectrum of diseases or to be used as alternatives to different organic and non-organic chemical products due to their significant bioactivities [9][10]. In Morocco, medicinal herbs have always been linked to both traditional and cultural practices [11][12].

R. monosperma is considered one of the medicinal plants rich in bioactive compounds, including alkaloids, polyphenols, flavonoids, fatty acids, and condensed tannins, as proved by several studies [3][13][14][15][16]. It has been extensively used in folk medicine in a wide range of countries; for example, used as an effective antihelmintic, disinfectant, and abortifacient and also to treat skin damages and cicatrization [3].

R. monosperma has attracted considerable interest due to its wide range of pharmacological properties, including antioxidant [17], anti-aging [3], antibacterial [18], antifungal [19], anti-inflammatory, antiproliferative, and antitumoral [3][11][20], as well as antileukemic activities [21]. The principal alkaloids of *R. monosperma* are retamine, sparteine, dehydrosparteine, ammodendrine, N-methylcytisine, cytisine, isolupanine, and anagyrine [22], flavonoids such as genistein, quercetin, 6-methoxykaempferol, and kaempferol [16], fatty acids from the seeds’ hexane extract, such as myristic, pentadecylic, oleic (omega-9), linoleic (omega-6) and linolenic (omega-3) [23]. It was found that *R. monosperma* exhibited an anti-aging effect that could enhance the expression of genes that play a role in wound healing and skin regeneration, such as sirtuin 1 (SIRT1) and SIRT3 in the HaCaT human keratinocyte cell line [3]. In addition, this plant showed potent antimicrobial effects and could be used to formulate medicinal plants for the management of various infectious conditions. It has been reported that hexane and dichloromethane extracts of seeds showed a very significant (Ø > 14 mm) antibacterial effect against *Bacillus sp* and *E. coli*, while the ethyl acetate extracts of the stems and the flowers exhibited very significant activity on *Salmonella sp* [18]. As an antifungal activity, alkaloids of *R. monosperma* play a significant role in the reduction of *C. albicans* and *C. tropicalis* growth. Furthermore, previous investigations have proven that *R. monosperma* has a promising anti-inflammatory effect; it is suggested that this species could be an option for developing an herbal medicine for inflammatory bowel disease due to its ability to reduce the production of pro-inflammatory cytokines such as COX-2 and iNOS [23]. Moreover, the findings of certain investigations have demonstrated that *R. monosperma* extracts showed beneficial antitumoral effects on human cervical adenocarcinoma cell lines (HeLa and SiHa) proliferation and apoptosis [3]. In addition to this, *R. monosperma* can be a candidate for traditional use as an antileukemic plant because it has been revealed to contain several unsaturated fatty acids, particularly linoleic acid, which is considered to be beneficial in cancer [24]. Concerning the antioxidant activity of *R. monosperma*, it has been observed to exert powerful effects against oxidative

stress-mediated pathological processes, which are attributed to the presence of flavonoids in ethyl acetate extracts of seeds, more specifically [17]. The literature in the previous year's reports contains a number of reviews on the phytochemistry and biological functions of several bioactive compounds of different parts of *R. monosperma*, but comprehensive investigations focusing on their health benefits are missing. This calls for further coordination on the state of knowledge to analyze the full potential pharmacological effects of the main bioactive compounds of different parts of this Mediterranean plant to better understand its benefits to human health and explore its clinical applications and pharmaceutical industries.

2. Chemical Composition

The chemical compounds of *R. monosperma* are rich in bioactive constituents belonging to different chemical classes, such as terpenoids, flavonoids, phenolic acids, fatty acids, and alkaloids. **Table 1** shows the chemical composition of *R. monosperma* according to plant parts.

Table 1. Chemical composition of *R. monosperma*.

Part of the Plant	Extract	Major Component	Ref
Stems	**Methanol** **Dichloromethane** **n-Butanol** **Ethyl acetate** **Chloroform**	**Polyphenols** **Flavonoids** **Condensed tannins**	[13][14]
	Methanol	**Alkaloid:** • Retamine • Sparteine • Dehydrosparteine • Ammodendrine • N-Methylcytisine • Cytisine • 17-Oxosparteine • Isolupanine • 5,6-Dehydrolupamine • Anagyrine • Lupanine	[15][17][18][19][22][25]

Part of the Plant	Extract	Major Component	Ref
Flower	Methanol	**Polyphenols** **Flavonoids** **Condensed tannins** **Alkaloids**	[13][14]
	Dichloromethane	**Polyphenol** **Flavonoid** **Tannins**	[14]
	Toluene	**Polyphenol** **Flavonoid** **Condensed tannins**	[13]
	Diethyl ether	**Polyphenol** **Flavonoid:** • Genistein, • Taxifolin • Quercetin, • 6-methoxykaempferol • Kaempferol	[3]

Part of the Plant	Extract	Major Component	Ref
Seeds		**Polyphenols** **Flavonoids** **Condensed tannins**	[13][14]
	Methanol	**Alkaloid:** • N-methylcytisine, • Dehydro-cytisine, • Cytisine, • 5,6-Dehydrolupanine, • Thermopsine • Ammodendrine • Anagyrine	[13][15][17][18][19][25][26][27]
	n-Butanol	**Polyphenols** **Flavonoids** **Condensed tannins**	[13]
	Hexane	**Fatty Acids:** • Myristic acid • Pentadecylic acid • Palmitic acid • Palmitoleic acid • Margaric acid • Stearic acid • Oleic acid (Omega 9) • Linoleic acid (Omega 6) • Linolenic acid (Omega 3) • Arachidic acid • Behenic acid • Lignoceric acid • Lauric acid • Tricosanoic acid • Palmitoleic acid • Pentadecanoic acid	[2][21][23][28]
	Dichloromethane	**Polyphenols** **Flavonoids** **Tannins**	[14]

Part of the Plant	Extract	Major Component	Ref
Leaves	Ethyl acetate	**Polyphenol** **Flavonoid** • Taxifolin • Genistein, • Quercetin, • 6-methoxykaempferol • Kaempferol • Condensed tannins	[3][13][14][15]
	Methanol	**Mineral:** **Al, Ba, Cd, Cu, Fe, Mg, Pb, Zn, Mn, Ca, K, Na, P** **Alkaloid:** • Sparteine • Dehydrosparteine • β−Isosparteine • Ammodendrine • N-Methylcytisine • Cytisine • 17-Oxosparteine • Isolupanine • 5,6-Dehydrolupamine • Anagyrine	[21][23] [15][17][18][25]
	Hexane	**α-Linolenic acid** **Sterols:** • Campesterol • Stigmasterol • β-Sitosterol	[4]
	Ethyl acetate	**Ethyl palmitate** **Phenol: (2,4-Ditertbutylphenol)**	[29]
	n-Butanol	**Methyl palmitate** **Methyl 7-octadecenoate** **Alkaloid: (Sparteine)** **Phenol: (Carvacrol)**	[29]
	Dichloromethane	**Alkaloid:** • Anagyrine • Sparteine	[30]

Part of the Plant	Extract	Major Component	Ref
Branches	**NaOH 4%**	**Monosaccharides:** • Rhamnose • Arabinose • Fucose • Xylose • Mannose • Glucose • Galactose • Galacturonic Acid • Glucuronic Acid	[31]
Whole plant	**Aqueous**	**Flavonoid:** • Daidzin • Rutin • Genistin • Daidzein • Luteolin • Apigenin • Genisetein	[16]

2.1. Polyphenols, Flavonoids, and Tannins

Polyphenols, flavonoids, and tannins, which are organic compounds found abundantly in plants, have become an emerging field of interest in nutrition in recent decades. *Retama monosperma* can be considered one of the plants rich in those compounds, as proven by several studies [3][13][14][15][16]. Previous studies have aimed to identify specific compounds present in *R. monosperma* through various identification methods [16][29]. Conversely, other authors have chosen to qualitatively quantify the content of certain groups of molecules, such as polyphenols, flavonoids, and condensed tannins, without identifying each individual compound [13][14]. Belmokhtar et al., 2014 reported that ethyl acetate extract has the highest polyphenol content in any of the stems, flowers, and seeds [13], while Hamdani et al. recorded in 2018 that the highest total polyphenols contents were reported in the methanol extract of the stems and the methanolic extract of the flowers showed a higher tannins content than the other extracts [14]. In 2021, Selaimia et al. successfully identified several compounds present in *Retama monosperma* using dried and crushed leaves as the source material [29]. The compounds were identified using GC/MS analysis. Among the compounds identified were two phenol compounds, carvacrol, which was found in the butanol extract, and 2,4-di-tert-butylphenol (**Figure 1**), which was identified in the ethyl acetate extract [29]. Earlier in 2013, González-Mauraza et al. identified seven flavonoid molecules in the aqueous extract of *Retama monosperma*, and these molecules are daidzin, rutin, genistin, daidzein, luteolin, and apigenin, and the main flavonoid was genistein [16].

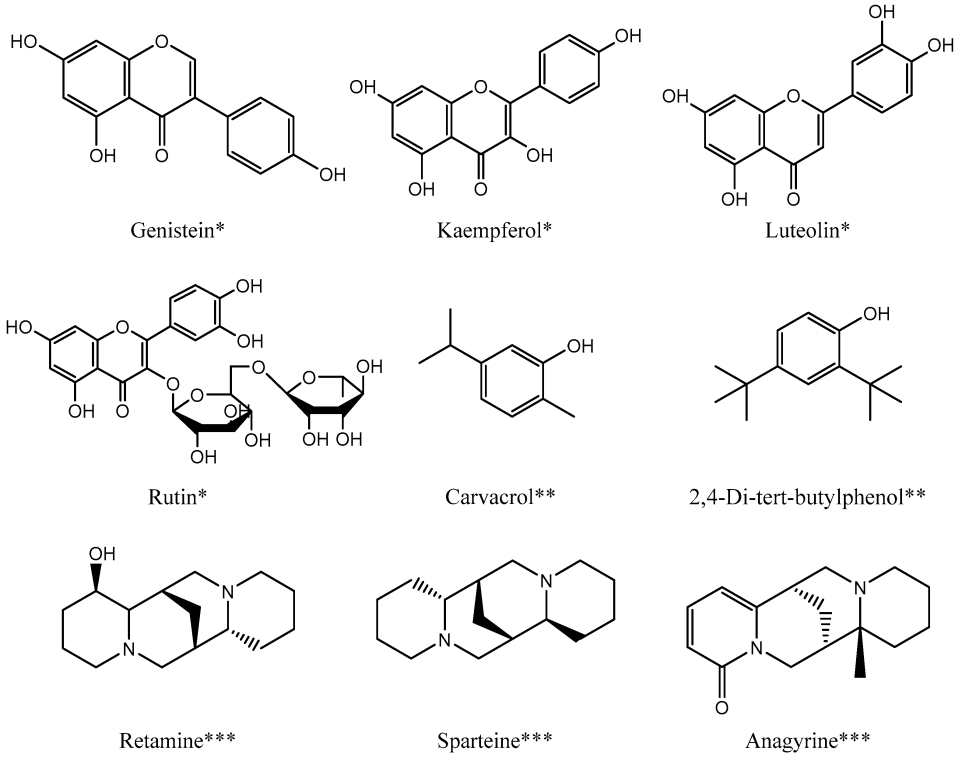

Figure 1. Some chemical structures of flavonoids (*), phenols (**), and alkaloids (***) were isolated from *Retama monosperma*.

2.2. Alkaloids

Alkaloids are a diversified structural group of natural products, and these molecules have a vast array of biological activities; many of them have significant pharmacological applications. In 1980, Antonio Salatino and Otto R. Gottlieb reported the presence of five quinolizidine alkaloids by GLC-MS in *Retama monosperma,* and these alkaloids are retamine, sparteine, anagyrine, cytisine and N-methylcytisine [22]. In addition to these molecules, A. El-Shazly et al. isolated four other alkaloids in 1996, including ammodendrine, 17-oxosparteine, lupanine and 5,6-dehydrolupanine, from stems and seeds of *Retama monosperma* using CLC and GLC-MS [19].

Another study was conducted by N. Merghoub et al. in 2011 on the dichloromethane fraction of the *Retama monosperma* leaves, and the results led to revealed five known quinolizidine alkaloids as well as sparteine, L-methylcytisine, 17-oxosparteine, and lupanine and anagyrine as a major alkaloid (**Figure 1**) [30]. In 2012, a study by Fdil et al. showed the presence of these alkaloids in the three parts of the methanolic extract of *Retama monosperma* (stems, leaves and seeds) with the identification of four new alkaloids, which are dehydrosparteine and isolupanine in the stems and leaves, dehydrocytisine in the seeds and β-isolupanine in the leaves [25], and since then, several investigations have been carried out showing the presence of these alkaloids with different percentages depending on the part of the plant and/or the solvent used during extraction [15][17][18][26][29].

It is noted that in most cases, the seeds contain mainly cytisine, while in the stems and leaves, sparteine and anagyrine are the predominant alkaloids.

2.3. Fatty Acids

The fatty acids present in the lipid and hexane seeds and cladodes extracts of *R. monosperma* were analyzed using GC/MS. The results of the analysis are presented in **Table 1**, which shows the presence of oleic acid (Omega 9), linoleic acid (Omega 6), linolenic acid (Omega 3), arachidic acid, myristic acid, pentadecylic acid, palmitic acid, palmitoleic acid, margaric acid, stearic acid, behenic acid, lignoceric acid, lauric acid, tricosanoic acid, palmitoleic acid, and pentadecanoic acid [2][21][23][28].

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