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Review

Chemistry and pharmacology of *Rhaponticum carthamoides*: A review

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ABSTRACT

Rhaponticum carthamoides (Willd.) Iljin is a perennial herb, commonly known as a maral root or Russian leuzea, which has been used for centuries in eastern parts of Russia for its marked medicinal properties. This review based on 117 literary sources, with many of them being originally published in non-English languages (mainly in Russian), discusses the current knowledge of traditional uses, chemistry, biological effects and toxicity of this species. Several different classes of compounds were previously isolated from various parts of *R. carthamoides* of which the main groups are steroids, particularly ecdysteroids, and phenolics (flavonoids and phenolic acids) accompanied with polyacetylenes, sesquiterpene lactones, triterpenoid glycosides and terpenes (essential oil). A comprehensive account of the chemical constituents is given in this review (figures of 120 structures are shown). Various types of preparations, extracts and individual compounds derived from this species have been found to possess a broad spectrum of pharmacological effects on several organs such as the brain, blood, cardiovascular and nervous systems as well as on different biochemical processes and physiological functions including proteosynthesis, work capacity, reproduction, and sexual function. Moreover, the extracts and preparations from the plant, which are hopefully safe, exhibited various additional biological effects e.g. antioxidant, immunomodulatory, anticancerogenic, antimicrobial, antiparasitic and insect antifeedant or repellent activities. The results of data analysis on the chemical, pharmacological and toxicological characteristics of *R. carthamoides* support the view that this species has beneficial therapeutic properties and indicate its potential as an effective adaptogenic herbal remedy. Finally, some suggestions for further research on chemical and pharmacological properties are given in this review.

Contents

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1. Introduction

Rhaponticum carthamoides (Willd.) Iljin (family Asteraceae), commonly known as a maral root or Russian leuzea, is a perennial herb, up to 150 cm high (Figs. 1 and 2), endemic in the Altai and Saian Mountains of South Siberia, where it naturally occurs in the alpine and subalpine meadows at 1200–2300 m above sea level (Selivanova, 1979; Lotocka and Geszprych, 2004). During the last few decades, the plant has been introduced to various regions of Central and Eastern Europe, where it is now widely grown for its marked medicinal properties (Opletal et al., 1997). The history of *R. carthamoides* as a medicinal plant began ages ago when local hunters in Altai observed the behaviour of the maral deer (*Cervus elaphus sibiricus*), which seemed to restore its strength after feeding on its roots. Their observation gave the traditional name "maral root" to the plant and initiated its use by local healers (Hlava and Valicek, 1989). In traditional medicine of Siberia, it has long been used in cases of overstrain and common weakness after illness (Petkov et al., 1984). In the last century, the muscle- and strength-building qualities of *R. carthamoides* have been thoroughly investigated in Russia, and various preparations have been commonly used by elite Soviet and Russian athletes in order to upgrade psychological and physical reserves which were exhausted by hard training (Gadzhieva et al., 1995). Currently, the extracts or some compounds from roots and rhizomes are used for their adaptogenic and tonic properties in various dietary supplements or nutraceutical preparations to promote muscle growth, treat impotency, eliminate physical weakness and mental weariness, as well as for recovery after surgery, infectious disease or chemical intoxication. They are also included in the formulas of various non-alcoholic beverages, cosmetic and bath products. Dried underground or aerial parts are included in herbal teas (Opletal and Opletalova, 1990; Opletal et al., 1997).

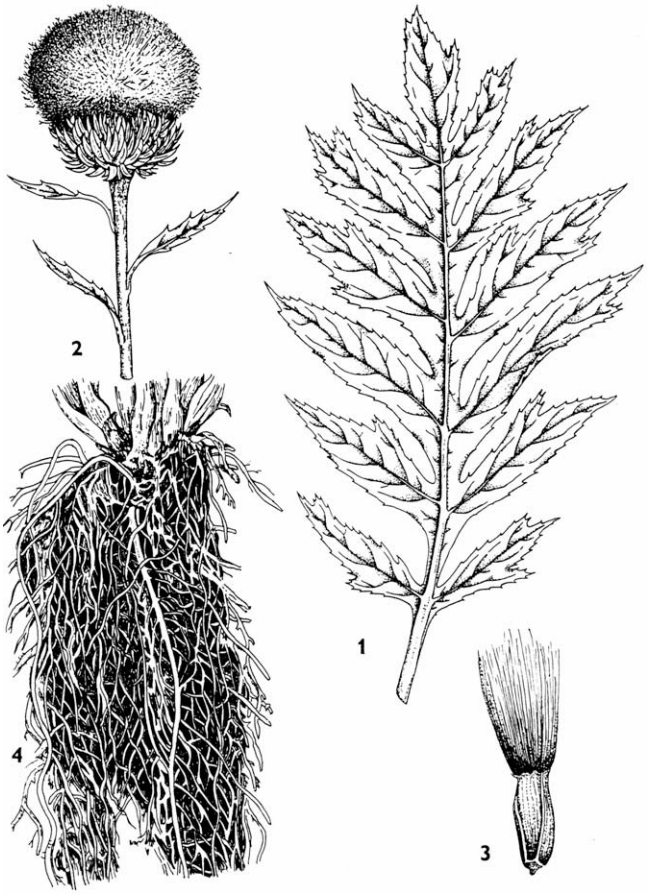

Fig. 1. Line drawing of *R. carthamoides*: 1. leaf, 2. inflorescence, 3. fruit, 4. roots (Valicek et al., 2001).

From a botanical point of view, it should be noted that the nomenclature of the genus is particularly confusing because many species of other genera are synonymous (Klein, 2004). Various species of the genera *Centaurea*, *Cnicus*, *Fornicium*, *Leuzea*, *Serratula*, and *Stemmacantha* are commonly listed in plant databases as synonyms for *R. carthamoides* (The International Plant Names Index, 2004). A particular question is whether to employ the name *Leuzea carthamoides* DC. or *R. carthamoides*. A recent treatment of the Cardueae tribe has chosen the latter (Greuter, 2003), suggesting that *L. carthamoides* be an additional synonym, which is, however, still widely used in many pharmacological and phytochemical studies. Nevertheless, despite many previous attempts to elucidate systematics of the genus (e.g. Dittrich, 1973; Holub, 1973, 1974; Soskov, 1978) including the latest one by Greuter (2003), the taxonomical status of the *R. carthamoides* appears to be still unclear and needs more detailed consideration.

2. Chemical composition

Several different classes of compounds were previously isolated from various parts of *R. carthamoides*, with the main groups being steroids, particularly ecdysteroids, and phenolics (Lamer-Zarawska et al., 1996; Opletal et al., 1997).

One of the earlier phytochemical reports regarding ecdysteroids of *R. carthamoides* revealed the isolation of 20-hydroxyecdysone (20E), known previously as β-ecdysone, ecdysterone or polypodine A (**1**), and inokosterone (**12**) from its underground parts (Krasnov et al., 1977). Further investigations identified 20E as the most abundant ecdysteroid in various parts of the plant with a content of 0.04–0.81%, 0.03–1.22% and 0.27–1.51% of dry matter for roots, aerial part and seeds, respectively (Yakubova and Sakharova, 1980; Varga et al., 1986; Opletal and Opletalova, 1990; Repcak et al., 1994; Timofeev et al., 1998). During more than 30 years of intensive research on the chemistry of *R. carthamoides*, 50 various ecdysteroid compounds (Table 1) have been detected in roots, aerial parts or seeds of the plant (Baltaev and Abubakirov, 1988; Girault et al., 1988; Baltaev, 1992a,b, 1995; Pis et al., 1994; Baltaev et al., 1997; Ramazanov et al., 1997a,b; Sadykov et al., 1997; Borovikova and Baltaev, 1999; Borovikova et al., 1999; Vokac et al., 2002; Budesinky et al., 2008). Several sterols, such as β-sitosterol, stigmasterol, Δ7-avenasterol, campesterol, and cholesterol have been detected in the roots (Khomova et al., 1995) and cholesterol, stigmasterol, β-sitosterol, and β-sitostanol in seeds of the plant (Stransky et al., 1998). The structures of ecdysteroids, shown as Fig. 3, were verified using The Ecdysone Handbook (Lafont et al., 2002).

Regarding *R. carthamoides* phenolic compounds, several authors reported the presence of various flavonoids or anthocyanins (Table 2, Fig. 4) in the roots, aerial parts and inflorescences of the plant (Vereskovskii and Chekalinskaya, 1979; Vereskovskii, 1980a,b; Dombi et al., 1989; Varga et al., 1990; Faizieva et al., 1999; Sharaf et al., 2001; Miliauskas et al., 2005; Koleckar et al., 2008a,b). Hajdu et al. (1998) isolated (*E*)-3,3′-dimethoxy-4,4′-dihydroxystilbene (**108**), a substance biogenetically closely related to flavonoids, from the roots of the plant. Besides the flavonoids, a number of phenolic acids (Vereskovskii and Chekalinskaya, 1978; Skiba and Werglarz, 1999, 2003), several lignans (Harmatha and Dinan, 2003; Harmatha et al., 2007), such as carthamogenin (**103**), carthamoside (**104**), trachelogenin (**105**), or tracheloside (**106**), and tannins e.g. ellagic acid (**107**) have also been detected in both underground and aerial parts of the species. Recently, the serotonin phenylpropanoids, namely *N-(Z)*-feruoylserotonin (**99**), *N-(Z)*-isoferuoylserotonin (**100**), *N-(E)*-feruoylserotonin (**101**), and *N-(E)*-isoferuoylserotonin