Review:
The endless nutritional and pharmaceutical benefits of the Himalayan gold, *Cordyceps*; Current knowledge and prospective potentials

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Abstract. Elkhateeb WA, Daba GM. 2020. Review: The endless nutritional and pharmaceutical benefits of the Himalayan gold, *Cordyceps*; Current knowledge and prospective potentials. Biofarma J Nat Prod Biochem 18; 70-77. As a traditional medicine, *Cordyceps* has long been used in Asian nations for maintaining vivacity and boosting immunity. Numerous publications on various bioactivities of *Cordyceps* have been investigated in both in-vitro as well as in *vivo* studies. Nevertheless, the role of *Cordyceps* is still arguable whether it acts as food supplement for health benefits or a real healing drug that can be prescribed in medicine. The *Cordyceps* industry has developed greatly and offers thousands of products, commonly available in a global marketplace. In this review, focus will be on introducing the ecology of *Cordyceps* and their classification. Moreover, elucidation of the richness of extracts originated from this mushroom in nutritional components was presented, with description of the chemical compounds of *Cordyceps* and its well-known compounds such as cordycepin, and cordycepic acid. Furthermore, highlights on natural growth and artificial cultivation of famous *Cordyceps* species were presented. The health benefits and reported bioactivities of *Cordyceps* species as promising antimicrobial, anticancer, hypcholesterolemic, antioxidant, antiviral, anti-inflammatory, organ protective agent, and enhancer for organ function were presented.

Keywords: *Cordyceps*; cultivation; secondary metabolites; traditional medicine

INTRODUCTION

Commonly seen nowadays on shelves of pharmacies and drug stores, and recommended for many benefits as boosting immunity, the genus *Cordyceps* is an ascomycetous traditional medicinal mushroom that is famous for having numerous bioactive compounds. *Cordyceps* have different common names as insect mushroom, caterpillar fungus, Himalayan gold, and much more, but the name *Cordyceps* originates from the Latin words (cord) which means ‘club’, and (ceps), referring to ‘head’. The fruiting bodies of these fungi appear from the head of different life stages of various orders of insects (Wang and Yao 2011), numerous species of Thitarodes caterpillars, and its most common host, the Himalayan bat moth *Hepialus armoricanus* (Chen et al. 2000). *Cordyceps militaris* (also known as orange caterpillar mushroom) is rich in bioactive compounds and hence have medical-biological activities in a similar way to *Cordyceps sinensis* (Shrestha and Sung 2005; Gong et al. 2006; Ma et al. 2007; Huang et al. 2009; Das et al. 2010; Dong et al. 2012). In this review, ecology, classification, nutritional components, chemical composition, natural growth and artificial cultivation, health benefits and reported bioactivities of famous *Cordyceps* species were discussed.

The most famous and widely used species of *Cordyceps* is *C. sinensis* (Berk.) Sacc (syn. *Ophiocordyceps sinensis* (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora). Currently, the preferred scientific name is *Cordyceps sinensis* (Berk.) Sacc. (Devkota et al. 2006). This species has wide host range including different species of Lepidopteran larvae (Wang and Yao 2011), numerous species of Thitarodes caterpillars, and its most common host, the Himalayan bat moth *Hepialus armoricanus* (Chen et al. 2000). *Cordyceps militaris* (also known as orange caterpillar mushroom) is rich in bioactive compounds and hence have medical-biological activities in a similar way to *Cordyceps sinensis* (Shrestha and Sung 2005; Gong et al. 2006; Ma et al. 2007; Huang et al. 2009; Das et al. 2010; Dong et al. 2012). In this review, ecology, classification, nutritional components, chemical composition, natural growth and artificial cultivation, health benefits and reported bioactivities of famous *Cordyceps* species were discussed.

CORDYCEPS ECOLOGY

Many *Cordyceps* species grow by feeding on insect larvae and sometimes on mature insects. *Cordyceps* grow on different insects, crickets, cockroaches, bees, centipedes, black beetles, and ants. From the genus *Cordyceps*, there are several species known to have medical value, only few are cultivated and the most
common and well known are *Cordyceps sinensis* (Figure 1) and *Cordyceps militaris* (Figure 2) (Halpern Georges 2007). *Cordyceps* may grow also on other arthropods as well as the fungus *Elaphomyces* Nees.

### Table 1. Current classification system of *Cordyceps* (*Cordyceps* sensu lato)

<table>
<thead>
<tr>
<th>Genus</th>
<th>No. of species</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Partial Clavicipitaceae</strong></td>
<td></td>
</tr>
<tr>
<td>Drechmeria</td>
<td>2</td>
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<tr>
<td>Hypocrella</td>
<td>50</td>
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<tr>
<td>Metacordyceps</td>
<td>4</td>
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<tr>
<td>Metarhizium</td>
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<tr>
<td>Nomuraea</td>
<td>3</td>
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<tr>
<td>Pochonia</td>
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<tr>
<td>Podocrella</td>
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</tr>
<tr>
<td>Regiocrella</td>
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</tr>
<tr>
<td>Sphaerocondyceps</td>
<td>2</td>
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<tr>
<td>Tyrannicordyceps</td>
<td>5</td>
</tr>
<tr>
<td>Total: 10</td>
<td>110</td>
</tr>
<tr>
<td><strong>Ophiocordycipitaceae</strong></td>
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</tr>
<tr>
<td>Blistum</td>
<td>1</td>
</tr>
<tr>
<td>Didymobotryopsis</td>
<td>3</td>
</tr>
<tr>
<td>Elaphocordyceps</td>
<td>1</td>
</tr>
<tr>
<td>Haptocillium</td>
<td>8</td>
</tr>
<tr>
<td>Hirsutella</td>
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<tr>
<td>Hymenostilbe</td>
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<tr>
<td>Ophiocordyceps</td>
<td>155</td>
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<tr>
<td>Paraisaria</td>
<td>2</td>
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<tr>
<td>Perennicordyceps</td>
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<tr>
<td>Polycyphalomyces</td>
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<tr>
<td>Purpureocillium</td>
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<tr>
<td>Syngiocladium</td>
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<tr>
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<tr>
<td>Trichosterigma</td>
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<tr>
<td>Total: 15</td>
<td>335</td>
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<tr>
<td><strong>Cordycipitaceae</strong></td>
<td></td>
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<tr>
<td>Akanthomyces</td>
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<tr>
<td>Ascopolyporus</td>
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<td>Beejasamha</td>
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<tr>
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<tr>
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<td>Engyodontium</td>
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<tr>
<td>Gibellula</td>
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<td>Hyperdermium</td>
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<td>Insecticola</td>
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<tr>
<td>Isaria</td>
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<td>Lecanicillium</td>
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<tr>
<td>Microhium</td>
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</tr>
<tr>
<td>Phytocordyceps</td>
<td>1</td>
</tr>
<tr>
<td>Pseudogibellula</td>
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<tr>
<td>Rotiferophthora</td>
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<tr>
<td>Simplicillium</td>
<td>8</td>
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<tr>
<td>Torrubia</td>
<td>66</td>
</tr>
<tr>
<td>Total: 18</td>
<td>467</td>
</tr>
</tbody>
</table>

Total: 3 families, 43 genera and 912 species

Note: The data is counted from Catalogue of Life: http://www.catalogueoflife.org/, access in June 2017.

Classification of the genus *Cordyceps* was previously within family Clavicipitaceae, order Hypocreales (the old genus *Cordyceps* Fr.). Currently, many genera have segregated from the genus *Cordyceps* such as *Metacordyceps*, *Tyramnycondyceps* (placed in family Clavicipitaceae); *Elphvordyceps*, *Ophiocordyceps* (in family Ophiocordycipitaceae); *Sphaerocondyceps*, and remaining *Cordyceps* species (placed in Incertae sedis within Hypocreales). Due to their special nutritional and healing values, *Cordyceps* is widely spreading in China, with a huge existing domestic market. In Chinese market, *Cordyceps* is known as ‘Dongchong Xiacao (worm in winter, herb in summer; *O. sinensis* (Berk.) Sung et al. 2007) which is the most expensive type and only produced from the Tibetan Plateau; other *Cordyceps* species in the markets are termed ‘fake Dongchong Xiacao’.
THE NUTRITIONAL COMPONENTS IN CORDYCEPS

Cordyceps is rich in various compounds, which are considered nutritional such as vitamins (K, B1, B2, B12, and E); essential amino acids. Additionally, many mono-, di-, and oligosaccharides, and many complex polysaccharides were found in Cordyceps besides trace elements (Na, K, Zn, Cu, Mg, Al, Fe, Cr, Cu, Mn, Zr, Pt, Se, Si, Sr, Ti, Ga, V, and Ni), proteins, nucleosides, and sterols. Cordyceps contains considerable quantities of polysaccharides, which represent 3-8% of mushroom total weight, and these polysaccharides are usually originated from fruiting bodies. Cordyceps polysaccharides, are considered as the major biologically active compounds besides nucleotides (Zhou et al. 2009; Mishra and Yogesh 2011; Elkhateeb et al. 2019).

CHEMICAL COMPOSITION OF THE MOST COMMON CORDYCEPS SPECIES

Cordyceps sinensis (Berk.) Sacc. is considered as the most expensive and well-studied Cordyceps species. According to different chemical analyses, C. sinensis contains proteins, polysaccharides, fats, fiber, carbohydrate, the famous bioactive compounds cordycepin (30-deoxyadenosine) and cordycepic acid (D-mannitol), and different vitamins (Ohta et al. 2007; Zhou et al. 2009).

The therapeutic potentials of Cordyceps depend mainly on the key actions of increased oxygen utilization, ATP production, and sugar metabolism stabilization. Many bioactive compounds originated from Cordyceps are responsible for those effects, such as cordycepin, cordycepic acid, some polysaccharides, vitamins, and trace elements. Till now, the full bioactive compounds existing in C. sinensis are not yet identified. However, at least the two compounds, cordycepic acid, and cordycepin, have been identified and recommended as important bioactive compounds. Of all Cordyceps species, C. militaris is the only species that has been successfully cultivated and most intensively studied. Majority of Cordyceps products available in the markets are developed from the fruiting bodies of cultivated C. militaris. According to reported chemical investigations, C. militaris contains cordycepin, adenosine, polysaccharide, mannitol, trehalose, polyunsaturated fatty acids, δ-tocopherol, p-Hydroxybenzoic acid and β-(1→3)-D-glucan (Reis et al. 2013; Liu et al. 2014; Smiderle et al. 2014; Wen et al. 2017; Elkhateeb et al. 2019).

CORDYCEPS NATURAL GROWTH AND ARTIFICIAL CULTIVATION

The natural growing fruiting bodies of Cordyceps are rare and their collection is an expensive process. Moreover, natural populations of key Cordyceps species are decreasing rapidly due to over-collection (Stone 2008; Zhang et al. 2012), presenting the need for increased in-vitro cultivation of Cordyceps using artificial medium. While over 400 species under the genus Cordyceps have been identified, only 36 species have been successfully cultivated in artificial media (Sung et al. 1999; Yin and Qin 2009). The first large scale fruiting techniques used for growing Cordyceps reduced the natural growing cycle from 5 to 2 years, this technique included breeding the host larvae, Thitarodes (Hepialus), then placing about 100 larvae into shoe carton sized plastic containers covered with lids, which are filled with grassland soil containing roots and tubers of their natural foods collected from the wild, besides other roots from cultivation. Spores of C. sinensis were inoculated after two years and about 10% of the larvae were actually taken over by Cordyceps and grew stromata (Yue et al. 2013). On the other hand, Arora et al. (2013) succeeded in using submerged conditions for culturing Cordyceps sinensis at pH 6 and temperature 15°C.

In previous studies, the medium used for growth of C. sinensis was sabouraud’s dextrose supplemented with yeast extract broth medium, and different additives, carbon, and nitrogen sources were also investigated (Arora et al. 2009). The highest number of conidia was obtained under the physical stress of freeze-shock (Ren and Yao 2013). Sucrose has been reported as the best-tested carbon source for the growth of C. Sinensis. Similarly, beef extract and yeast extract were the best nitrogen sources (Seema et al. 2012). Furthermore, using folic acid meaningfully increased the yield, and adding calcium chloride and zinc chloride as micro and macronutrients, one-to-one, increased the yield significantly. One of the optimum artificial techniques for culturing of C. sinensis was utilizing sterile rice media at 9- 13°C for 40-60 days, then to induce stroma production temperature was lowered to 4°C, and at 13°C for 40 days for developing fruiting bodies (Cao et al. 2015). It should be highlighted that the growth of Cordyceps mycelium is mainly affected by some environmental factors, and many factors such as temperature, growth media, and pH (Calam 1971), but after testing various media, potato dextrose agar was confirmed to be the optimum medium at pH ranging between 8.5-9.5 at 20-25°C (Ruhul et al. 2008).

Artificial cultivation is achieved by inoculating reared larvae with cultured strains and the infected larvae were monitored and fed indoors for one or two years. After that, C. sinensis could be collected. (Lo et al. 2013). C. militaris cultivation is much easier than C. sinensis in both solid and liquid media using different carbon and nitrogen sources, since C. militaris can complete its life cycle when cultured in-vitro (Shrestha et al. 2004, Xiong et al. 2010). Artificial cultivation of C. militaris mycelium on synthetic media has recently been advanced especially for the goal of cordycepin production using different methods such as surface culture (Masuda et al. 2007) and submerged culture (Mao et al. 2005). Usually, C. militaris stromata production requires 35-70 days (Zhang and Liu 1997; Du et al. 2010). Culture duration depends on many conditions such as the amount of medium, shape, and volume of the culture container. The development of C. militaris stroma cultivation in-vitro started with using insects to grow stromata by Leatherdale (1970) followed by laboratory
trials using various organic substrates by Yue et al. (1982). For commercial production of C. militaris stromata, cereals including rice have been widely used (Wen et al. 2008; Chen et al. 2011). Also, using substrates such as wheat grains, cottonseed coats, corn cobs, corn grain, bean powder, millet, and sorghum have shown promising results (Chen and Wu 1990; Zhang and Liu 1997; Gao and Wang 2008, Wei and Huang 2009). The optimum organic substrate currently used is a mixture of rice and silkworm pupae (Shrestha et al. 2005, Sung et al. 2006; Jin et al. 2009). Furthermore, brown rice, malt, and soybean were found to be important sources of nutrition for C. militaris in comparison with chemical media (Xie et al. 2009). C. militaris cultivation needs a relatively low level of nitrogen (Gao et al. 2000) which may explain lower yields when using insects in comparison with higher yields reached when cereals were used in the culture. Plant hormones such as colchicines, 2, 4-D, citric acid triamine can promote C. militaris stroma production. Also, potassium, calcium, and magnesium salts can increase the yield of fruiting bodies (Xiao et al. 2010).

Myelia production for the aim of large scale production of bioactive compounds is also achievable and has been performed in submerged culture (Huang et al. 2006; Xie et al. 2009; Das et al. 2010). C. militaris cultivation has been improved, which results in successful production of high yield of stromata and elevated cordycepin content (Sun et al. 2009; Du et al. 2010). Production of fruiting bodies has been studied for three successive generations (Hong et al. 2010; Xiao et al. 2010; Shrestha et al. 2012; Xiaoli et al. 2014).

**CORDYCEPS AND HEALTH BENEFITS**

The genus Cordyceps species are extensively studied due to the uncountable number of medical-biological activities used by their extracted compounds, with various medical and nutritional values. In traditional Chinese medicine, the main use of Cordyceps has been in the treatment of asthma and other bronchial conditions, and giving energy and sexual power. Recent research now confirms the competence of Cordyceps in many other fields. One of the advances of modern research has been the discovery of cordycepin, which has a potent antibacterial action against majority of bacterial species that have currently developed resistance to other commonly used antibiotics. Cordyceps showed remarkable activity during treating tuberculosis and human leukemia, as shown in many clinical trials in Asia and elsewhere (Halpem Georges 2007). Cordyceps was shown to improve the maximum amount of oxygen and to improve respiratory function. Other components produced by Cordyceps sinensis include the deoxynucleoside 2', 3' deoxyadenosine. Also, Quinic acid derived from cordycepin obtained from Cordyceps, exerts antimicrobial and antiviral activities. Many studies have reported the potency of Cordyceps sinensis in healing heart rhythm disturbances such as chronic heart failure and cardiac arrhythmia (Mishra and Yogesh 2011; Wang et al. 2012).

**Anticancer activities of Cordyceps**

Various Cordyceps originated bioactive compounds having promising anticancer activity that were previously reported (El-Hagrassi et al. 2020). For example, cordycepin showed antitumor activity against B16 melanoma cells (Yoshikawa 2004 and 2007). In addition, cordycepin inhibited the mammalian target of rapamycin complex 1 in gallbladder cancer cells in-vitro resulting in loss of cancer cell viability and apoptosis (Wong et al. 2010; Ferreira et al. 2010; Wu et al. 2014). C. militaris was found to inhibit U937 cells growth in a dose-dependent manner and limit human leukemia (Park 2005). Cordyceps has shown promising results in slowing and inhibiting the growth of cancer cells (Santhosh Kumar et al. 2014) and in some cases could reduce tumor size (Nakamura et al. 2003). Clinical trials on cancer patients have been conducted in many Asian countries, showing talented results in reducing tumor size (Wang et al. 2001), improving tolerance for chemotherapy and/or radiation (Zhou et al. 1998) and in stimulating the immune system which, hence, enhances the efficiency of chemotherapy (Shin et al. 2003). Crude extract of C. militaris showed potent anticancer activity in a xenograft mouse model with RMA cell-derived tumors (Park et al. 2017). Additionally, some Cordyceps species have anti-leukemia activities and better suppressive effects of chemotherapy on bone marrow function as a model for cancer treatment (Liu et al. 2008; Wong et al. 2010; Ferreira et al. 2010).

**Hypoglycemic and hypocholesterolemic effect**

Cordyceps are found to regulate and also lower the blood sugar levels by improving metabolism of glucose and conserving hepatic glycogen (Zhao et al. 2002; El-Hagrassi et al. 2020). Cordyceps can increase secretion of glucokinase and hexokinase which are glucose regulating enzymes secreted by the liver (Kim et al. 2017). Polysaccharides are the key player in showing the hypoglycaemic activity of Cordyceps. For example, CS-F30, a polysaccharide extracted from C. sinensis culture mycelium has been reported for its promising hypoglycaemic effect (Kiho 1996). Additionally, the plasma glucose level was reduced quickly after intravenous administration of CS-F30 in normal and streptozocin-induced diabetic mice (Kiho 1996). Another polysaccharide (CS-F10), was purified from a hot-water extract of C. sinensis cultured mycelia and consists of galactose, glucose, and mannose in a molar ratio of 43:33:24. CS-F10 lowers the plasma glucose level in normal, adrenaline-induced hyperglycaemic and diabetic mice. Hypercholesterolemic is an indicator for high risk of cardiovascular attack. El-Hagrassi et al. (2020) reported the role of C. militaris in lowering the total cholesterol level and the level of triglycerides. A hot-water extract of C. sinensis mycelia has been found to reduce total cholesterol concentration in the serum of mice, by reducing LDL(low-density lipoprotein) hypocholesterolemic activities (El-Hagrassi et al. 2020). A hot-water extract of C. sinensis mycelia has been found to reduce total cholesterol concentration in the serum of mice, by reducing LDL and
very-low-density lipoprotein, and increasing good cholesterol concentration (HDL cholesterol) (Koh 2003).

**Improving kidney functions and liver disorders**

Some clinical trials revealed that the administration of *C. sinensis* could significantly improve kidney function and boost overall immunity of patients diagnosed with chronic renal failure (Guan et al. 1992). Additionally treating patients with gentamicin-induced kidney damage helped in recovering 89% of normal kidney function in a relatively short time (Zhou et al. 1990). The mode of kidney enhancing action of *Cordyceps* is explained by its ability to protect sodium pump activity of tubular cells, increase 17-ketosteroid and 17-hydroxycorticosteroid levels in the human body, reduce content of calcium in certain tissues, and accelerate regeneration of tubular cells (Zhou et al. 1990; Xu et al. 1995; Wang et al. 1998). *Cordyceps* is commonly used for the treatment of chronic hepatitis B and C. Using the antiviral drug, lamivudine, plus mixed extracts of *Cordyceps* with other medicinal mushrooms showed promising results for treating hepatitis B (Wang and Shiao 2000; Ng and Wang 2005; Zhou et al. 2009). On the other hand, daily consumption of *Cordyceps* improved liver functions in patients suffering from post-hepatic cirrhosis (Zhu and Liu 1992; Zhou et al. 2009). *Cordyceps* extracts is used to help in the healing of both chronic hepatitis B and C (Wang and Shiao 2000).

**Cordyceps as antioxidant and antiaging activities**

One of the most potent bioactivities reported for *Cordyceps* extracts is their ability to protect cells from being damaged by free radicals. This activity is corresponding to polysaccharide fraction (Yu et al. 2007; Wang et al. 2012). *Cordyceps sinensis* has potent antioxidant and anti-aging properties (Yamaguchi et al. 2000; Ji et al. 2009). Also, many studies elucidated the antioxidant effect of extracts obtained from *C. militaris* (El-Hagrassi et al. 2020). The fruiting bodies extract of *C. militaris* showed strong DPPH radical scavenging activity, which indicated high antioxidant activity, while the fermented mycelia extract had stronger total antioxidant activity, and reducing capability (Dong et al. 2014). *Cordyceps* has been used for centuries as a remedy for weakness and fatigue by residents living in the high mountains of Tibet to give them energy which is achieved by increasing cellular ATP (Holliday et al. 2008). Nowadays, *Cordyceps* is utilized by athletes to overcome weakness and fatigue, and to increase endurance and boost energy levels (Liu et al. 1997). Moreover, clinical trials connecting chronic fatigue with aging patients revealed that treatment with *C. sinensis* resulted in improvement of fatigue and dizziness, increasing cold intolerance, and amnesia (Mizuno, et al. 1999; Chen et al. 2013; Wu et al. 2014).

**Cordyceps for organs and glands protection**

*Cordyceps sinensis* also has clear effects on other organ systems (Chen 1995; Zhang and Yuan 1997; Guo and Guo 2000; Xu 2006). For example, in the central nervous system, *C. sinensis* has sedative, anticonvulsant and cooling effects. On the respiratory system, *C. sinensis* has a potent relaxant action on bronchi, noticeably increases secretion of adrenaline from the adrenal glands, and also participates in tracheal contraction caused by histamine; it additionally has an expectorant, antitussive, and anti-asthmatic effects, and it also inhibits pulmonary emphysema. On the endocrine system, *C. sinensis* has effects as a male hormone. Polysaccharides extracted from *Cordyceps* can increase corticosterone levels in plasma. *Cordyceps* is used in traditional medicine for decades to improve men’s fertility. A study has proven the positive effect of using *C. militaris* mycelium on sperm motility, morphology, productivity, and enhancement of sexual activity (Lin et al. 2007). *Cordyceps* extracts contain adenosine, deoxyadenosine, related adenosine type nucleotides, and nucleosides which help in stabilizing heartbeat and correcting heart arrhythmias (Pelleg and Porter 1990).

**Cordyceps as anti-inflammatory**

Commonly, the famous cordycepin is the compound causing the anti-inflammatory activity of numerous *Cordyceps* species (Won and Park 2005; Kim et al. 2006; Yang et al. 2011). *C. militaris* ethanolic extracts of cultured fruiting bodies and mycelia exerted an anti-inflammatory activity on the chick embryo chorioallantoic membrane angiogenesis, and in the croton oil-induced ear edema in mice (Won and Park 2005). On the other hand, an alkaline extract of *C. militaris*, showed a strong anti-inflammatory effect against formalin-induced nociception and LPS-induced peritonitis in mice, due to containing a potent anti-inflammatory compound (linear b- (1R3)-D-glucan) (Smiderle et al. 2014; Park et al. 2015). Adenosine is also extracted from *Cordyceps* species with numerous activities related to avoiding tissue damage as anti-inflammatory properties (Nakav et al. 2008; Tsai et al. 2010; Liu et al. 2015).

**Cordyceps as antiviral agents**

Many studies reported that cordycepin extracted from *C. militaris* can inhibit infection with human immunodeficiency virus (Mueller et al. 1991). Cordycepin has shown antiviral activities against different viruses such as plant viruses, and human viruses (influenza virus, Epstein-Barr virus, murine leukemia virus) (Ryu et al. 2014). Till now, the mode of killing or inhibiting actions of cordycepin is not fully understood, but number of studies have elucidated the ability of cordycepin to inhibit numerous protein kinases (Glazer and Kuo 1977; Jin et al. 2011; Elkhateeb et al. 2019). On the other hand crude extract of fruiting bodies of *C. militaris* showed promising in-vitro antivotavirus SA-11 agents activities (El-Hagrassi at al. 2020).

**Cordyceps side effects and safety**

*Cordyceps* is generally safe in recommended dosage and no major side effects were reported. (Das et al. 2010).
CONCLUDING REMARK

Cordyceps and its bioactive components and metabolites are golden mines with therapeutic potential against various fatal diseases. Developing new techniques capable of cultivating species other than *Cordyceps militaris* can contribute to producing enough quantities of bioactive compounds such as cordycepin, and cordycepic acid, and which also may lower cost of this expensive medicinal mushroom. On the other hand, further in vivo studies should be conducted in order to evaluate clinical activities of Cordyceps metabolites which can be a step to certify its use as a medical drug.

REFERENCES


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