

## A RECENT UPDATE ON THE PHYTOCHEMISTRY, PHARMACOLOGY, CULTIVATION, AND THERAPEUTIC USES OF CORDYCEPS MILITARIS: A REVIEW

\*Pankaj Sharma\*\* Raju L

\*Government College of Pharmacy Rohru, Shimla, Himachal Pradesh

\*\*Government Pharmacy College Seraj, Mandi, Himachal Pradesh

Name of corresponding Author: Pankaj Sharma

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### Corresponding Author:

E-Mail:

pankajsharmadrugs@gmail.com

### ABSTRACT

The parasitic fungus species *Cordyceps militaris*, which is a member of the *Cordyceps* genus, has received a lot of interest lately because of its many pharmacological qualities and possible therapeutic advantages. The goal of this study is to provide an overview of what is currently known about *C. militaris* and its uses in many disciplines. Traditional Chinese medicine has long utilised *cordyceps militaris* for its alleged therapeutic benefits, which include immune system stimulation, anti-inflammatory actions, and possibly anti-tumour effects. Recent research has concentrated on the bioactive components of this plant, including cordycepin, adenosine, and polysaccharides, which have shown promise in improving antioxidant capacity, immunological response, and regulating a variety of medical diseases. *C. militaris*, a supplement that's well-liked by sportsmen and fitness enthusiasts, has the potential to boost stamina and athletic performance. Studies suggest that its consumption may encourage the utilisation of oxygen, leading to improved endurance and decreased fatigue during physical exercise. This review also looks at the possibilities of *C. militaris* in the culinary world, where it is renowned for its distinct flavour and nutritional makeup. It provides a wealth of vital amino acids, vitamins, and minerals as a functional meal. In summary, *C. militaris* offers a potential area for more study and use in both conventional medical and contemporary applications. Its bioactive components and possible health benefits make it an interesting subject for current review. This review aimed at understanding *C. militaris* chemical composition, cultivation, and broad variety of uses in health, nutrition, and sports, as well as its full therapeutic potential.

**Keywords:** Cordyceps Militaris, Pharmacology, Therapeutic uses, Cordycepin

## 1. INTRODUCTION

The unique species of parasitic fungi *Cordyceps militaris*, sometimes known as the "caterpillar fungus," is a member of the *Cordyceps* genus<sup>1</sup>. It is recognised for its distinctive biology, fascinating life cycle, and a variety of uses in conventional medicine and the culinary arts. Due to its alleged health advantages, *C. militaris*, which has origins in a number of parts of the world, including Asia, North America, and Europe, has been utilised for millennia in traditional Chinese and Tibetan medicine<sup>2</sup>. It usually parasitizes insects and other arthropods in nature, consuming their tissue and sprouting a stalk-like structure that eventually produces spore-bearing structures. Because it was previously noted to parasitize insect larvae, particularly caterpillar larvae, this parasitic association with insects has contributed to its common name<sup>3</sup>. *C. militaris* has drawn a lot of interest recently due to possible health-promoting qualities. Various bioactive substances, including polysaccharides, nucleosides, sterols, and cordycepin, are thought to be present in it. These substances have been shown in studies to have antioxidant, anti-inflammatory, immunomodulatory, and anticancer activities<sup>4</sup>. Due to these qualities, *C. militaris* has been the focus of in-depth scientific research and is a popular component in the creation of herbal remedies and dietary supplements. Additionally, *C. militaris* has made its way into the culinary world, giving a variety of foods a distinct flavour and nutritional profile. It is frequently used in Asian soups, stews, teas, and even desserts<sup>5</sup>. It is

a versatile component in contemporary gastronomy with a flavour that has been characterised as both sweet and savoury. It goes well with both savoury and sweet meals. Due to the difficulties of wild gathering and the issues with habitat conservation, *C. militaris* cultivation has become more popular<sup>6</sup>. To produce *C. militaris* on a big scale, researchers and growers have created novel growth methods. These methods entail growing the fungus in controlled environments on a variety of substrates, such as cereals, rice, or other organic components<sup>7</sup>.

## 2. TAXONOMY OF *CORDYCEPS MILITARIS*

*C. militaris* is a species of parasitic fungus belonging to the Ascomycota phylum. Taxonomically, it is classified as follows:

**Kingdom:** Fungi

**Phylum:** Ascomycota

**Class:** Sordariomycetes

**Order:** Hypocreales

**Family:** Cordycipitaceae

**Genus:** *Cordyceps*

**Species:** *militaris*

This classification follows the standard hierarchical structure used in biological taxonomy, progressing from the broadest category (kingdom) to the most specific (species). Here below the figure no. 1 showing the general appearance of *C. militaris*

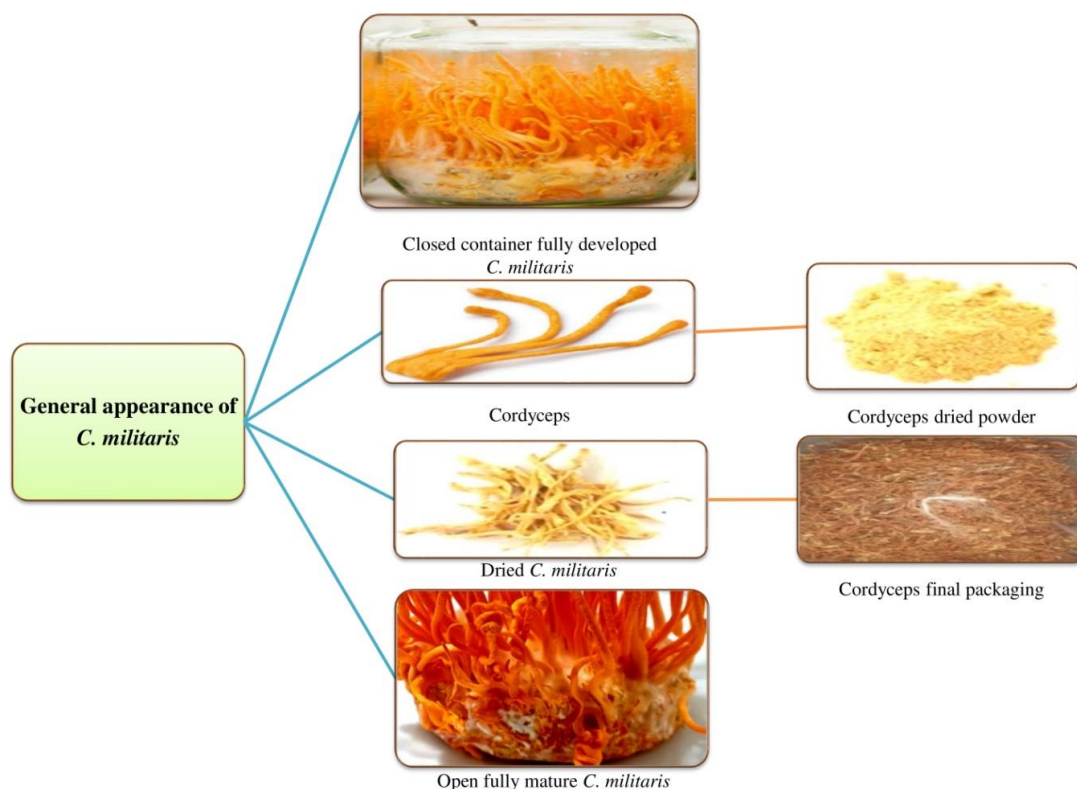


Figure no. 1 General appearance of *C. militaris*

### 3. MORPHOLOGY CHARACTER OF CORDYCEPS MILITARIS

The Cordycipitaceae family of parasitic fungus includes the species *C. militaris*. Its morphology may be explained in terms of the many structures and developmental<sup>8</sup>. The 1<sup>st</sup> phase Mycelium is the term for the network of threadlike structures that *C. militaris* uses to begin its life cycle<sup>9</sup>. Hyphae, which are long, thin, branching filaments that make up mycelium and take up nutrients from the substrate it is growing on, are what give it its structure. The 2<sup>nd</sup> phase stroma is significant component of *C. militaris* is the stroma. It develops from the substrate and is the portion of the fungus that is visible<sup>10</sup>. The stroma can be a few millimetres to several centimetres in size and is frequently club-shaped or cylindrical<sup>11</sup>. Typically, this portion of the fungus is collected for use in food and medicine. The 3<sup>rd</sup>

phase Perithecia is sexual spores (ascospores), which are flask-shaped structures, are housed in perithecia, which are present in the stroma of *C. militaris*<sup>12</sup>. These perithecia create spores to reproduce and are enmeshed in the stroma. The 4<sup>th</sup> phase Ascospores is a sexual spores generated within the perithecia are known as ascospores. They are allowed to germinate and spread naturally in the environment, where they eventually produce new mycelium and begin the life cycle over again<sup>13</sup>. Some strains of *C. militaris* are capable of producing apothecia, which are fruiting bodies with a cup- or saucer-like form. For reproduction, apothecia discharge spores (ascospores) into the atmosphere<sup>14</sup>.

### 4. PHYTOCHEMICAL CONSTITUENTS

The parasitic fungus *C. militaris* mostly affects insects and other arthropods. Due to its possible

health advantages, it has been employed in traditional Chinese and Tibetan medicine.<sup>15</sup> Plants and fungi create substances called

phytochemicals that may have a variety of biological impacts<sup>16</sup> as shown in figure no. 2.

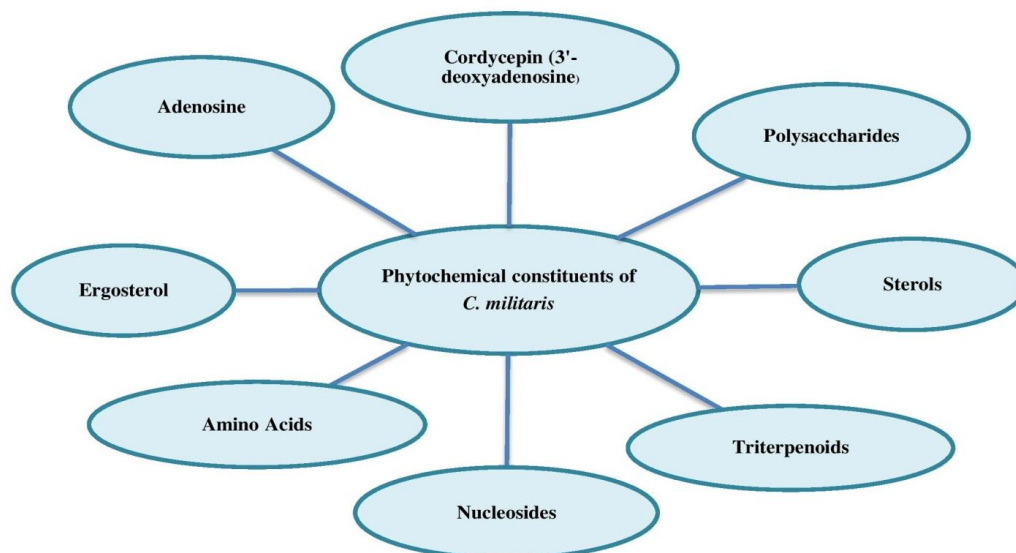


Figure no.2 showing the Phytochemical constituents in *C. militaris*

One of the most well-known and extensively researched bioactive substances in *C. militaris* is cordycepin (3'-deoxyadenosine)<sup>17</sup> as shown in the figure no.3. Its potential anti-inflammatory, anticancer, antiviral, and immunomodulatory

activities have all been studied<sup>18</sup>. A nucleoside, adenosine shares structural similarities with cordycepin. It participates in a number of physiological processes and may have effects that are anti-inflammatory and antiplatelet<sup>19</sup>

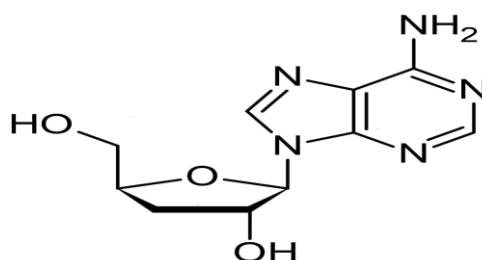


Figure no. 3 showing the structure of Cordycepin (3'-deoxyadenosine)

Numerous polysaccharides, or complex carbohydrates, are found in *C. militaris*. It has been suggested that polysaccharides may have immunomodulatory and antioxidant properties<sup>20</sup>. A sterol substance called ergosterol is present in the cell membranes of fungus. When exposed to ultraviolet (UV) light, it can become vitamin D<sup>21</sup>.

A number of bioactive molecules may be synthesised from ergosterol. Sterols are a class of substances that are present in both plants and fungus and are structurally related to cholesterol<sup>22</sup>. They may cut cholesterol and reduce inflammation, according to certain theories. Essential and non-essential amino acids

are among the several amino acids found in *C. militaris*<sup>23</sup>. Proteins are made up of amino acids, which are also necessary for many bodily physiological activities. Other nucleosides may also be found in *Cordyceps militaris* in addition to cordycepin and adenosine<sup>24</sup>. Nucleosides are substances made up of a sugar molecule and a nucleobase (such as adenine). A family of substances known as terpenoids may have pharmacological effects, such as anti-inflammatory and antioxidant actions<sup>25</sup>.

## 5. PHARMACOLOGY

The *Cordyceps* genus contains a species of fungus called *C. militaris*, which has long been utilised in traditional Chinese medicine<sup>26</sup>. *C. militaris* has grown in favour recently due to its pharmacological and prospective health advantages<sup>27</sup>. Here are some probable *C. militaris* pharmacological characteristics and health advantages as shown in figure no.4.

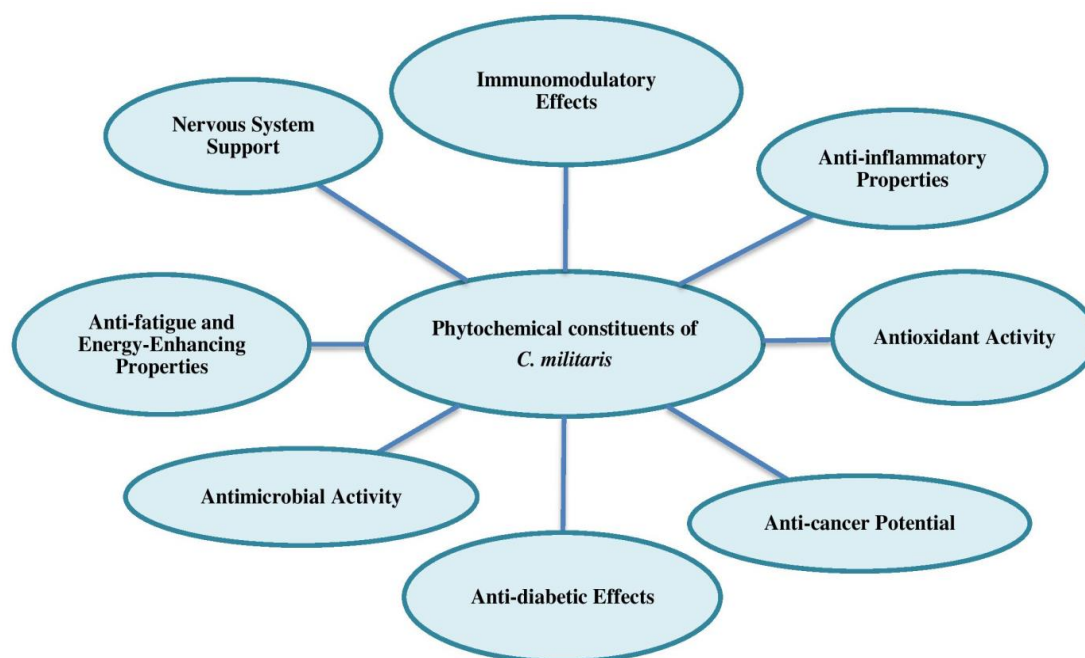


Figure no. 4 Showing the Pharmacological activity of *C. militaris*

**Immunomodulatory Effects:** It has been demonstrated that *C. militaris* possesses immunomodulatory capabilities, which may improve the immune system's response to infections and illnesses<sup>28</sup>.

1. **Anti-inflammatory Properties:** According to certain research, *C. militaris* may have anti-inflammatory properties that are useful for treating inflammatory diseases<sup>29</sup>.
2. **Antioxidant Activity:** Bioactive substances found in *C. militaris* have antioxidant effects,

which may help prevent oxidative stress and lessen cellular damage<sup>30</sup>.

3. **Anti-cancer Potential:** According to research, *C. militaris* may have potential anti-cancer properties and may be utilised as a supplemental therapy for cancer. It could stop cancer cell proliferation and cause cancer cell apoptosis (programmed cell death)<sup>31</sup>.
4. **Anti-diabetic Effects:** *C. militaris* is a possible supplementary therapy for diabetes

since it may have a favourable effect on blood sugar levels and insulin sensitivity<sup>32</sup>.

5. **Anti-fatigue and Energy-Enhancing Properties:** Because *C. militaris* is said to promote physical performance, boost energy, and lessen weariness, it is favoured by athletes and anyone looking to increase their endurance<sup>33</sup>.
6. **Antimicrobial Activity:** It's possible that *C. militaris* has antibacterial qualities that can help fight against several viral and bacterial illnesses<sup>34</sup>.
7. **Nervous System Support:** According to some study, *C. militaris* could help the nervous system, which might benefit neurological health and cognitive performance<sup>35</sup>.
8. **Hepatoprotective Properties:** Hepatoprotective properties of *C. militaris* may help shield the liver from injury brought on by poisons or illnesses<sup>36</sup>.

Before utilising *C. militaris* supplements, it is imperative to speak with a medical practitioner, especially if you have any underlying medical issues or are taking medication. Under the direction of a doctor, the dosage, supplementation type, and potential drug interactions should be carefully evaluated.

## 6. THERAPEUTIC SIGNIFICANCE *C. MILITARIS*

Various civilizations have utilised a form of fungus called *C. militaris* in traditional medicine, notably traditional Chinese medicine (TCM) and traditional Korean medicine. The fungus has been utilised for generations for its alleged therapeutic characteristics as well as for its alleged health advantages. *C. militaris* is frequently employed in traditional Chinese medicine (TCM) to bolster the yin of the kidney and lung<sup>37</sup>. It is said to assist the respiratory system, improve lung function, and hydrate the kidneys. It can be used by TCM practitioners to

treat ailments including exhaustion, asthma, a persistent cough, and respiratory problems<sup>38</sup>. The immune system has historically been boosted by *C. militaris*. It is said to strengthen the body's inherent defence systems, increasing its resistance to infections and diseases. *C. militaris* has traditionally been used to increase physical stamina and endurance<sup>39</sup>. It has been utilised by traditional healers to enhance athletic performance, boost vitality, and lessen weariness. Its appeal among athletes and those looking to improve their physical performance is a result of this. According to custom, *C. militaris* is used to promote the health and vigour of the reproductive system and is said to have aphrodisiac effects<sup>40</sup>. It is frequently used to increase fertility, sexual function, and general vigour. *C. militaris* is thought to promote longevity and general wellbeing and has been linked to anti-aging qualities. It is thought to rejuvenate both the body and the psyche. *C. militaris* has been used traditionally, and it may be able to control blood sugar levels<sup>41</sup>. It helps folks who have diabetes or are trying to control their blood sugar levels. *C. militaris* is frequently used in conventional medicine to enhance kidney health and function. It is thought to improve kidney-related illnesses and may assist in treating renal problems<sup>42</sup>. Although *C. militaris* has a long history of traditional usage and is currently employed in a number of conventional medical procedures, it is crucial to emphasise that scientific research is still being conducted to better understand its possible health benefits and support its historical applications.

## 7. CULTIVATION OF *CORDYCEPS MILITARIS*:

A particular kind of fungus called *C. militaris* is utilised in traditional Chinese medicine and is recognised for its possible health benefits. *C. militaris* must be grown in a favourable setting with the right nutrients and environmental factors in order for it to flourish<sup>43</sup>. Here are some general instructions for raising and figure no. 5 showing flow chart cultivation of *C. militaris*.

- Substrate Preparation:** *C. militaris* typically grows on a substrate made of grains or other organic materials. Common substrates include rice, wheat, millet, oats, and a combination of these grains<sup>44</sup>.
- Sterilization:** The substrate needs to be thoroughly cleaned and sterilized to eliminate any competing organisms. This is usually done by autoclaving or pressure cooking the substrate<sup>45</sup>.
- Inoculation:** The substrate is inoculated with a culture of *C. militaris* after sterilisation and cooling. This culture can be obtained from a reliable source or a previously cultivated Cordyceps culture<sup>46</sup>.
- Incubation:** Place the infected substrate in an area that is clean, well-ventilated, and at the right temperature and humidity for incubation. Usually, 20-25°C (68-77°F) is the appropriate temperature for incubation. Watch for evidence of development on the substrate, which may take the form of white mycelium<sup>47</sup>.
- Colonization:** Over the course of many weeks, the substrate will be colonised by the mycelium of *C. militaris*. The mycelium will spread and take root throughout the substrate during this phase<sup>48</sup>.
- Fruiting Conditions:** Provide precise environmental conditions to encourage fruiting once the substrate has been completely colonised. This frequently entails reducing the temperature and regulating the humidity. 12–18°C (54–64°F) is typically the ideal fruiting temperature, and 80–90% humidity should be maintained<sup>49</sup>.
- Fruiting Bodies Formation:** When the right circumstances are present, *C. militaris* will begin to produce fruiting bodies, the fungus's visible, mature portions. These fruiting structures look like lengthy caterpillars<sup>50</sup>.
- Harvesting:** When the mature fruiting bodies are the proper size and colour, they are harvested. Usually, this occurs just before fruiting bodies produce spores and when they are completely formed<sup>51</sup>.
- Drying:** Use a dehydrator or leave the fruiting bodies in a well-ventilated location to dry them after harvesting. The effectiveness and purity of the Cordyceps are preserved by proper drying<sup>52</sup>.
- Packaging :** The dried Cordyceps *militaris* are carefully placed in the selected packaging material. Depending on the manufacturer's preference and the intended market, they may also be blended with other ingredients or kept pure. It's essential to prevent moisture from entering the package, as Cordyceps is hygroscopic and can readily absorb moisture<sup>53</sup>.
- Labeling;** Each package should be properly labeled with essential information, including the product name, weight, expiration date, batch/lot number, nutritional information (if applicable), and any certifications or quality assurance seals<sup>54</sup>.
- Storage:** To retain its effectiveness and purity, store the dried *C. militaris* in an airtight container in a cool, dry location away from the sun.

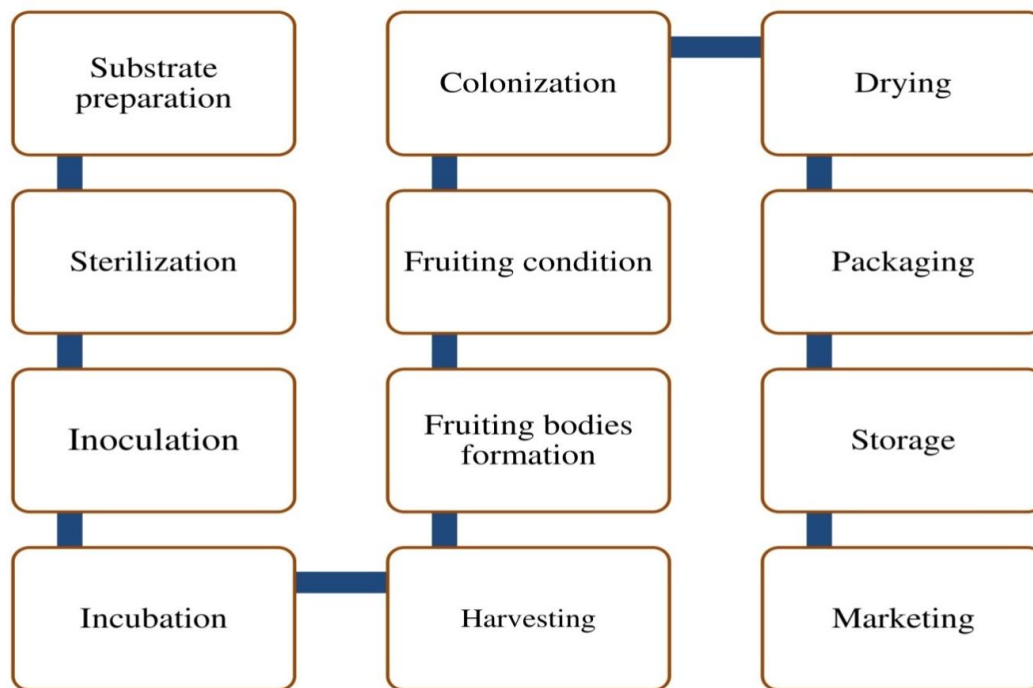


Figure no. 5 showing flow chart cultivation of *C. militaris*

A good *C. militaris* harvest depends on maintaining cleanliness and using sterile procedures throughout the cultivating phase. For a more thorough and customised approach to *C. militaris* production, it's also advised to speak with specialists or specialised growing instructions.

### 8. FUTURE POSSIBLE PRODUCT OF CORDYCEPS MILITARIS

*C. militaris* is a species of fungus that has gained popularity for its potential health benefits and uses in traditional medicine. Here are some possible products derived from *C. militaris*. *C. militaris* is often used to produce dietary supplements in various forms such as capsules, tablets, or powders<sup>55</sup>. These supplements are marketed for their potential immune-boosting, energy-enhancing, and adaptogenic properties. *C. militaris* can be processed to extract its bioactive compounds, which are often used in health products, functional foods, or beverages<sup>56</sup>. These

extracts may concentrate specific beneficial components like cordycepin, polysaccharides, adenosine, and other bioactive molecules. *C. militaris* can be used to create tinctures by soaking the fungus in alcohol or another solvent to extract its active compounds<sup>57</sup>. Tinctures are often used in traditional medicine and holistic health practices. *C. militaris* can be dried and ground into a fine powder. This powder can be used as an ingredient in various food and beverage products, including smoothies, teas, coffee, and health supplements<sup>58</sup>. *C. militaris* can be used in the fermentation process to create products such as Cordyceps-infused foods or beverages. Fermentation can enhance the bioavailability and digestibility of the active compounds. *C. militaris* extract can be incorporated into skincare products like creams, serums, or masks due to its potential skin benefits, such as anti-inflammatory and antioxidant properties<sup>59</sup>. *C. militaris* can be added to various food products like energy bars,



protein powders, or cereals to enhance their nutritional value and potential health benefits. Dried *C. militaris* can be used to make teas or infusions, providing a convenient way to consume the benefits of the fungus. *C. militaris* can be processed and encapsulated into easy-to-consume capsules or pressed into tablets for daily supplementation<sup>60</sup>. When using *C. militaris* products, it's important to consult with a healthcare professional, especially if you have underlying health conditions or are taking medications, to ensure safety and appropriate usage<sup>61</sup>.

### 9. FUTURE PROSPECTIVE OF CORDYCEPS MILITARIS

*C. militaris* is a species of fungus that has been used in traditional Chinese medicine and is gaining attention for its potential health benefits and various applications. *C. militaris* is known for its potential medicinal properties, including immune modulation, antioxidant activity, anti-inflammatory effects, and potential anti-tumor properties<sup>62</sup>. Future research may focus on further understanding and validating these health benefits, potentially leading to the development of novel therapeutic applications<sup>63</sup>. *C. militaris* is often used in nutraceuticals and functional foods due to its rich content of bioactive compounds, such as cordycepin, polysaccharides, and adenosine<sup>64</sup>. Continued research and development may lead to the incorporation of *C. militaris* into various food and beverage products

for enhanced nutritional value and potential health benefits. As research on *C. militaris* progresses, there may be an increased interest from the pharmaceutical industry in utilizing its bioactive compounds for the development of new drugs or supplements targeting specific health conditions<sup>65</sup>. *C. militaris* cultivation has gained traction, and ongoing research may optimize cultivation techniques to enhance its yield and bioactive compound content<sup>66</sup>. This could make it a viable crop for commercial cultivation and contribute to the biotechnology sector. The commercialization of *C. militaris* and its products could potentially lead to economic growth in regions where it is cultivated or harvested. Its increasing demand could create new opportunities for farmers and businesses<sup>67</sup>. Advances in research technologies and methodologies may enable a deeper understanding of the biochemical composition and mechanisms of action of *C. militaris*<sup>68</sup>. This could lead to the identification of new bioactive compounds and innovative applications in various fields.

### 10. RECENT ADVANCEMENTS IN RESEARCH IN CORDYCEPS MILITARIS

Over the years, the *C. militaris* has experienced a number of upgrades and innovations. The list of bio technology based industry that have been placed into them, as well as the process of production, has grown<sup>69</sup>. Table 1 lists the most recent improvements research in *C. militaris*

Researcher Name	Year	Project's Name	Findings of Note	Conclusions
Sung-Ho Kim	2013	Cultivation and Optimization	Optimized cultivation conditions for Cordyceps militaris, including temperature and media composition.	Improved cultivation methods enhance bioactive compound production.
Bo Yeon Kim	2016	Antioxidant Activity	Identified significant antioxidant activity in Cordyceps militaris extracts.	Suggested potential applications in health and wellness due to antioxidant properties.
Seung-Hwan	2017	Anti-Inflammatory	Demonstrated anti-	Implication for



Yang		Effects	inflammatory effects of Cordyceps militaris in in vitro and in vivo studies.	potential use in treating inflammatory conditions.
Eun-Hwa Sohn	2018	Immunomodulatory Activity	Showed immunomodulatory effects of Cordyceps militaris, enhancing immune responses in experimental models.	Indicated potential for immune system support.
Dae-Hyuk Kim	2019	Anti-Cancer Properties	Investigated anti-cancer properties of Cordyceps militaris, showing potential in inhibiting cancer cell growth.	Suggested further research for its application in cancer therapy.
Wan-Mo Kang	2020	Neuroprotective Effects	Demonstrated neuroprotective effects of Cordyceps militaris against neurotoxicity in cellular models.	Proposed as a potential therapeutic agent for neurodegenerative disorders.
Seong Hoon Kim	2020	Bioactive Compounds	Identified and characterized bioactive compounds in Cordyceps militaris, including cordycepin and adenosine.	Emphasized the potential health benefits associated with these compounds.
Ji Eun Kim	2021	Anti-Diabetic Effects	Explored the potential anti-diabetic effects of Cordyceps militaris, showing improved glucose metabolism in animal models.	Suggested as a natural approach to managing diabetes.
Jin-Hyung Lee	2021	Antiviral Activity	Investigated the antiviral activity of Cordyceps militaris against specific viruses, demonstrating inhibitory effects.	Suggested as a potential antiviral agent in the medical field.
Byung Hoon Jo	2021	Anti-Obesity Effects	Explored the anti-obesity effects of Cordyceps militaris, highlighting its potential in weight management and lipid metabolism.	Proposed as a natural remedy to combat obesity and related issues.

**11. Patents**

New patents in the research of *C. militaris* have recently been filed and accepted, and they have been used. As noted below, the authority has also industry shown in table 2.

granted further patents that will help shift demand towards Cordyceps militaris as a revolutionary Pharmaceutical/ Medical / Food i

S. No.	Patent title	Patent/ Grant number	Inventor	Grant Date	Country Patent
1.	Cordyceps militaris, single mating type strain 2461 and application thereof	CN108624510 /108624510	Yao yijian	27.10.2020	China
2.	Cordyceps militaris, strain having improved cordycepin production ability	KR10181085000 / 1018108540000	Lee & won jae	20.12.2017	Republic of Korea
3.	Cordyceps militaris, mutant strain for obtaining high-yield cordycepin and application of Cordyceps militaris, mutant strain	CN108220172 /108220172	Qiao yuchen	21.08.2020	China
4.	Production of whitening material using cordyceps militaris,	KR1020020013/1003767820000	Han & yeong hwan	19.03.2003	Republic of Korea
5.	Cordyceps militaris, strain and application thereof in cordycepin production	CN111117896 /111117896	Liu qingguo	13.07.2021	China
6.	Cordyceps militaris, mutant strain for obtaining high-yield cordycepin and application of Cordyceps militaris, mutant strain	CN108220172 /108220172	Qiao yuchen	21.08.2020	China
7.	Preparing process for organic germanium-contained cordyceps militaris,	KR1020010000513 /1004059900000	Kim, myeong gon, kim, seung & yoo, jin cheol	20.11.2003	Republic of Korea
8.	Liquid culture method for Cordyceps militaris, stroma	CN104472208 /104472208	Ji hong	15.02.2017	China

**CONCLUSION**

A parasitic fungus species called *C. militaris* has drawn a lot of interest because of its possible health advantages and wide range of uses. The pharmacological activities of this fungus, which include anti-inflammatory, immunomodulatory, antioxidant, and antibacterial actions, have been well researched. Its bioactive components,

including cordycepin, cordycepic acid, and polysaccharides, contribute to its medicinal qualities and may have a bright future as a treatment for a number of illnesses. According to research, *C. militaris* may promote immune system performance, support respiratory health, and increase stamina and exercise capacity. It has also been researched for its ability to control diabetes, improve liver and kidney function, and



has anti-cancer qualities. Including *C. militaris* with conventional medicine and contemporary medicines offers a viable path to creating brand-new health-improving goods. To confirm its effectiveness, dose, safety, and any potential adverse effects, further studies and clinical trials are required. To fully use the positive effects of *C. militaris* for human health and wellness, it is imperative to keep researching its mechanisms of action and comprehending its therapeutic potential.

### CONFLICT OF INTEREST

The authors declare no conflict of interest.

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