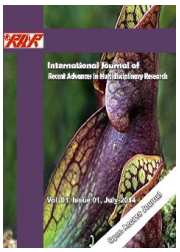
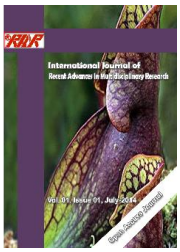


International Journal of Recent Advances in Multidisciplinary Research
Vol. 02, Issue 01, pp.0161-0170, January, 2015



Research Article

CORDYCEPS SINENSIS (BERK.) SACC.-AN ENTOMOPHAGOUS MEDICINAL FUNGUS - A REVIEW

***Rupesh Kumar Arora**

*Regional Research Station, Punjab Agricultural University, Bathinda, Punjab, Pin Code -151001(India)

ARTICLE INFO

Article History:
Received 15th October, 2014
Received in revised form
09th November, 2014
Accepted 31st December, 2014
Published online 31st January, 2015

Keywords:

Cordyceps sinensis (Berk.)
Sacc.
Entomophagous fungus,
Medicinal mushroom.

ABSTRACT

Cordyceps is an entomophagous fungus belonging to class ascomycetes and family Clavicipitaceae of the order Hypocreales and are known to parasitize the larvae, pupae or adults of insects. Of the 300 species reported, so far no other species is considered as medicinally important and costly as *Cordyceps sinensis* (Berk.) Sacc.. The fungus *Cordyceps sinensis* (Berk.) Sacc.. is native of high Himalayan mountains in Tibet, Nepal, India and Bhutan, at an altitude ranging from 3,000 to 5,000 m and are commonly known as 'yartsa-gunbu' in Tibet and as '*Keera ghas*' or '*Keera jhar*' (insect herb) in Indian mountains. In nature, it is parasitic on the larvae of a small moth, (*Hepialus armoricanus* family Hepialidae, order Lepidoptera). The caterpillar fungus *Cordyceps sinensis* (Berk.)Sacc.is a well-recognized medicinal mushroom. *Cordyceps sinensis* (Berk.) Sacc., the world's most efficient and expensive medicinal mushroom and considered as a traditional Chinese medicine having multiple medicinal and pharmacological properties and also used to treat respiratory and immune disorders, pulmonary diseases, renal, liver and cardiovascular diseases, hyposexuality and hyperlipidema. The pharmacological and medicinal significance of *Cordyceps sinensis* (Berk.) Sacc. mainly due to its bioactive ingredients i.e. Cordycepin,Adenosine, ergosterol etc.

INTRODUCTION

Cordyceps is an ascomycetous fungus (**Illana *et al*., 2007; Wu *et al*., 2010**) belongs to the class Pyrenomycetes, order Clavicipitales, family Clavicipitaceae and includes more than 300 species found worldwide (**Saccardo, 1883; Massee, 1895; Mains, 1940; Kobayasi, 1941; Mains, 1947; Rogers, 1954**). *Cordyceps* species are parasitic, mainly on insects and other arthropods (**Petch, 1921; Chen *et al*., 2002b**). Some of these are also parasitic on other fungi like the subterranean, truffle-like *Elaphomyces* (**Mains, 1957**) and also on spiders (**Mains, 1954**). *Cordyceps* species are particularly abundant and diverse in humid temperate and tropical forests, grows parasitically on larvae in high altitude grassland ecosystems. In historical and general usage the term "*Cordyceps*" usually refers specifically to the specific species *C. sinensis*, but there were also many other closely related species that come under the general term of *Cordyceps.* Berkely, the British Mycologist first described this fungus in 1843 as *Sphaeria sinensis* Berk. Later in 1878, Saccardo renamed it as *Cordyceps sinensis*. The accepted scientific name *Cordyceps sinensis* (Berk.) Sacc. is referred to the final form, which is the fruiting body of the fungus arising out of the dead body of a caterpillar (**Devkota, 2006**). *Cordyceps sinensis* (Berk.) Sacc. is an ascomycetous, entomophagous parasitic fungus of the family clavicipitaceae (**Arora and Singh, 2009b**). The caterpillar fungus *Cordyceps sinensis* (Berk.) Sacc.is a well-recognized medicinal mushroom (**Arora *et al*., 2008**). Early records of *Cordyceps* as medicines is as old as the Qing Dynasty in China and this information has been mentioned in Ben-Cao-Cong-Xin (New Compilation of Materia Medica) written by Wu-Yiluo in around 1757 (**Singh *et al*., 2008**). Medicinal use of *C. sinensis* by Tibetans has been documented for over 500 years. In Traditional Chinese Medicine, C. sinensis is commonly known as 'dong chong xia cao' meaning 'winter-worm summer grass' which is the literal translation of the Tibetan name (**Jones, 1997**). In interior mountain areas it is also locally known as 'Yarsha Gamboo', Keera ghas' and 'Keera jhar'. The name 'Yarsha Gamboo' means 'summer-grass winter-worm'. In literatures, 'Gunba', or 'Gonba', or 'Gumba' have also been used instead of 'Gamboo' (**Arora, 2008**). This term describes the life stages of C. sinensis. Tibetans believe that during winter time it lives as a 'worm' and later, as metamorphosis occurs at the start of the spring season, this worm transforms into a kind of 'grass' (**Singh *et al*., 2008**). Two distinct phases have been recognized during the entire transformation process. Firstly, the 'grass' starts growing from the head of the larva. A grass-like or blade-like part emerges out from the head of the insect larvae. The worm at this particular stage, appears to be white, is alive and can be seen moving over the ground.

****Corresponding author:Dr Rupesh Kumar Arora***
Regional Research Station, Punjab Agricultural University, Bathinda, Punjab, Pin Code -151001, India.

The blade-like part can be seen protruding out from the head of the insect like a tiny horn. This horn like structure continues to grow further. Ultimately, the worm or the insect dies and transforms into a brownish-yellow colored 'root' like structure of the grass (**Singh *et al*., 2008**); this being the fruiting body of this caterpillar mushroom.

In **Traditional Chinese Medicine**, Valued four times its weight in silver, it is used for lung protection, various reproductive disorders and also balancing 'Qi' which is the fundamental energy of life (**Jones, 1997**). *Cordyceps* was discovered about 1500 years ago in Tibet by herdsmen who observed that their livestock became energetic after eating it growing locally. About a thousand years later, the physicians of the Emperor of Ming Dynasty came to know about this wonderful mushroom and used this knowledge with their own wisdom to develop new and powerful medicines.

The first Chinese Emperor used this herbal/ medicinal mushroom as a tonic for longer life. The legendary Chinese beauty Yang Kue Fei (719-756 A.D.) who is reported to be the regular user of the herb credited this as her fountain of youth. The Chinese athletes consumed this fungus regularly and held many world records (**Steinkraus and Whitefield, 1994**). In ancient China, *Cordyceps* was used in the Emperor's palace and was considered to have ginseng (the tuber of an East Asian and North American plant, supposed to have medicinal properties) like properties. It was used to strengthen the body after exhaustion or long-term illness. Soon it was used for disorders like backache, impotency and other related problems as well as to cure opium addiction (**Zhu *et al*., 1998 a, 1998b**).

Comprehensive reviews on *C. sinensis* oriented towards modern medical science elaborate the use of this fungus alongwith other mushrooms in various treatments (**Lei, 1992; Wang and Shiao, 2000; Jason, 2005**). The number of studies indicate that *C. sinensis* (and also its mycelial extract) possess certain anti-cancer, anti-metastatic and immuno-stimulating properties and also have an anti-oxidant activity (**Yamaguchi *et al*., 2000; Li *et al*., 2001b; Singh *et al*., 2007**).The fruiting bodies and mycelial culture of *C. sinensis* have been and are still used for strengthening the immune system (**Hong and Li, 1990**) and for many types of ailments of heart, kidney, liver, circulatory system and for treating TB, asthma, back pain, reproductive disorders, cancer, etc. (**Hobbs, 1986; Manabe *et al*., 1996 ; Manabe *et al*., 2000**), apart from the treatment of Hepatitis B (**Zhou, 1990**). *Cordyceps sinensis,* a well known tonic food or invigorant with broad spectrum medicinal properties (**Zhen *et al*., 2011**), has been highly valued for the treatment of a wide range of diseases. (**Wu *et al*., 2007; Dong and Yao, 2008**).

Till date, there has been no organized result oriented attempts at its cultivation under controlled conditions. Due to these reasons more and more wild mushrooms are being harvested from nature every year in a reckless way. This could possibly lead to extinction of this mushroom from the natural habitats. Cultivated source for *C. sinensis* mushrooms will be a better sustainable alternative to wild *C. sinensis* harvested from nature and will lead to more stable pricing of its medicine. Laboratory culture of *C. sinensis* is typically by growth of the pure culture mycelium in liquid culture. Due to its peculiar characteristics, habitat, morphology and being a store house of medicinal properties, it is a highly prized mushroom.

Occurrence

In vernacular Cordyceps sinensis is named differently in different regions/countries viz. "Vegetable Wasps and Plant Worms" in Western countries, "Yartsa Gunbu" in Tibet (**Winkler, 2008**) and "Gadavira" in Nepal (**Hye, 1999**). In Nepal, Dolpa it is known by many names as Yarsagumba, Jara (Root), Kira (Insect), Jeevan buti Chyau (Life tonic mushroom) and Chyau Kira (mushroom insect) (**Devkota, 2006**). In India, it is known by the name of Ghas Ka Kira or Kira Jhar or Kira ghas (Pithoragarh) or Yartsa Gumba in alpine zones in Darma and Johaar Valleys in Pithoragarh in Kumaun Himalayas (**Negi, 2007**). Cordyceps is known as "Winter-Worm Summer Grass" or "DongChungHaCao" in Korea, "Totsu kasu" or "Tochukasu" in Japan and "DongChongXiaCao" in China (**Holliday and Cleaver, 2004**)

Distribution of C. sinensis is widespread and is reported from countries like India, China, Japan, Germany, U.S.A, Mexico, Canada, Denmark, and Italy. In China this mushroom grows naturally in the cold in high mountainous areas 3000-5000m above sea level in Sichuan, Qinghai, Xizang, Yunnan, around the Himalayas (**Gwangpo, 2000a**). The distribution of this fungus is limited to areas with an average annual precipitation of about 350-400 mm/annum. In general, Cordyceps is not found in areas where precipitation is below 300 mm/annum, such as the Chang-tang and other arid areas of the northwestern Plateau. C. sinensis is a fungus parasitizing the larvae of the insect belonging to the genus Thitarodes (Hepialus), which has its natural habitat in alpine grasslands of the Tibetan plateau. C. sinensis is endemic in the Tibetan Plateau including the adjoining high altitude areas of the Central and Eastern Himalayas (Nepal, Bhutan, and India's Uttarakhand, Sikkim, Himachal Pradesh and Arunachal Pradesh) (**Winkler, 2004**).

Native occurrence of the fungus is confined to the high Himalayan mountains in Tibet, Nepal and India, at an altitude ranging from 3000 to 5000m (**Singh *et al*., 2007**) and in some provinces of china. The most common occurrence of the fungus is between 3500 m and 4500 m elevation in cold and arid environment (**Sharma, 2004**). In India it has been collected from upper hilly regions of district Pithoragarh (Uttarakhand) at an altitude of 3200m from the snow meadows of Brahamkot, Ultapara, Ghawardhappa, Chhipalakot, Najari in Dharchula, Chetri Bugyal and Chipla Kedar (4000 m). It has also been collected from Nagin Dhura, Ralam Bugyal at the base of Panchachuli Hills, Laspa, Tolatop, Darti, Mapa top, Burfu Top, Milam Top in Johar Hills of Kumaun (**Negi, 2005**).

MORPHOLOGY

Ophiocordyceps sinensis (syn. *Cordyceps sinensis*) (**Weckerle *et al*., 2010 and Zhong *et al*., 2010**) is a parasite of caterpillars and is endemic to alpine regions on the Tibetan Plateau (**Shie *et al*., 2009**). *Cordyceps sinensis* parasitizes larvae of Thitarodes (Hepialus) moths (**Winkler, 2008**). The caterpillar-shaped Chinese medicinal mushroom *Cordyceps sinensis* (**Harsahay *et al*., 2010 and Wei *et al*., 2011**) consists of the fruiting body and the host caterpillar (**Yuan *et al*., 2007**). The ascocarp or fruiting body of the *C. sinensis* mushroom originates at the base on an insect larval host (usually the larva of the Himalayan bat moth (*Hepialus armonicanus*) although

occasionally other insect hosts besides the bat moth are encountered) and ends at the club-like cap, including the stipe and stroma (**Holliday and Cleaver, 2004**). The stroma is nearly twice as long as the caterpillar when fresh (**Winkler, 2004**). The fruiting bodies of Caterpillar fungi consist of head parts and parts that look like sacks. The head parts come in various shapes: a circle, a club, a cotton swab stick, a coral reef, noodles and a long oval (**Hye, 1999**). The fruit body is dark brown to black; and the 'root' of the organism (the larval body) pervaded by the mushroom's mycelium. The root has worm-like head, body and legs with numerous thin and fine transverse wrinkles. There are about eight pairs of legs on the body of the root and out of them four middle pairs are more prominent. Its lower part is thin while the upper part is slightly thicker (**Garbyal *et al.*, 2004**). Fruiting bodies of *C.sinensis* were 4-7 cm long over the caterpillar cadaver ranging 3-4 cm in size, mostly erect, stalked, slightly swollen at tip; emerged single, double or triple from the head of larvae (**Arora *et al*., 2013**). appears yellowish to brown in colour (**Holliday and Cleaver, 2004**). The colour varies widely red, yellow, purple, black, green, white, orange and olive (**Hye, 1999**). The immature larva, which forms the host upon which the *Cordyceps* grows, usually lives about 6 inches below ground (**Holliday and Cleaver, 2004**).

Cordyceps sinensis is a peculiar and a very different kind of fungus in the sense that it parasitizes the body of caterpillars, eats the soft tissue and mummifies the insect larvae. In all, it completes its lifecycle at the cost of the life of the insect.

Culturing of *Cordyceps sinensis* (Berk.) Sacc. in Laboratory conditions

C.sinensis are psychrophilic in nature.Attempts were made to culture in laboratory conditions. Multiplication of the fungus in submerged culture under specified conditions (pH – 6 and temperature 15 ºC) (**Arora, 2008 and Arora *et al*., 2013**) had potential advantages. The significant effect of nutritional sources i.e. carbon, nitrogen, vitamins and minerals on the growth of *C.sinensis* in SDY (sabouraud's dextrose with yeast extract) broth medium were noticed (**Arora and Singh, 2009b**). The amount of sugar found in *C. sinensis* mycelia cultured in SDY broth (63.1%) as compared to that in the fruiting bodies (24.2%). The protein content was higher in fruiting bodies (28.6%) as compared to *C.sinensis* mycelia (8.2%). The lipid content was (3.15%) in fruiting bodies and 2.95% in the mycelium of *C.sinensis* (**Arora and Singh, 2009a**).

Biochemical constituents of natural cordyceps

The chemical composition of Cordyceps was explored in 1951. In 1957, the constituents of C. sinensis were studied and a crystalline substance cordycepic acid was isolated (**Chatterjee *et al*., 1957**)The biochemical constituents of the C. sinensis fruit body, as reported by various workers is given as under: Cordycepic acid, glutamic acid, amino acids (phenylalanine, proline, histidine, valine, oxyvaline, arginine); Polyamines (1, 3-diamino propane, cadaverine, spermidine, spermine, homospermidine, and purtescine), Cyclic dipeptides (cyclo-(gly-pro), cyclo-(leu-pro), cyclo-(val-pro), cyclo-(ala-leu), cyclo-(ala-val) and cyclo-(thr-leu); Saccharides and sugar derivatives (d-mannitol, oligosaccharides, and polysaccharides); Sterols (ergosterol, delta-3 ergosterol, ergosterol peroxide, 3-sistosterol, daucosterol and campasterol); Nucleotides and nucleosides (adenine, uracil, uridine, guanine, guanosine, thymidine and deoxyuridine and cordycepin) 28 saturated and unsaturated fatty acids, their derivatives and other organic acids (oleic, linoleic, palmitic and stearic acids), Vitamins (B1, B2, B12, E and K),Inorganic elements (K, Na, Ca, Mg, Fe, Cu, Mn, Zn, Pi, Se, Al, Si, Ni, Sr, Ti, Cr, Ga, V and Zr) (**Xiao *et al*., 1983; Xu *et al*., 1988b; Sharma, 2004**). Cordycepin is one of the most imp constituent present in the C. sinensis, Cordycepin was first extracted from C. militaris (**Cunnigham *et al*., 1951**) and then found to be present in C. sinensis (**Huang *et al*., 2003**) and C. Kyushuensis (Ling *et al*., 2002). Cordycepin and cordycepic acid are regarded as the most important constituents of this fungus and owe high medicinal significance (**Cunnigham *et al*., 1951; Chatterjee *et al*., 1957; Sprecher and Sprinson, 1963**). Nucleosides in C. sinensis include adenosine and cordycepin (3'-deoxyadenosine), which have usually been assumed to be the bioactive ingredients and indices for estimation of the C. sinensis quality (**Hsu, 1999**).

Medicinal property and chemical constituents

Cordyceps sinensis, the world's most medicinal mushroom (**Holliday and Cleaver, 2008**) is a traditional chinese medicine has various pharmacological effects (**Mizuha *et al*., 2007**). The medicinal properties of *Cordyceps sinensis* are known due to the presence of bio-active components (**Arora *et al*., 2008**).

Medicinal Uses

Cordyceps sinensis (Berk.) Sacc., reputed medicinal fungus (**Jing *et al.*, 2011**) is well known as a Chinese Medicinal 'herb' used for its invigorating and immunological effects on the human body (**Jiang and Yao, 2002**). However, no other species is considered as powerful as *C. sinensis,* or is as costly (**Chen *et al.*, 2002a**). For medication, the fruiting body (fungus) and the worm (caterpillar) were used together. Worm had chemical composition similar to the fruiting body (**Li *et al.*, 2002**). The Tables of *C.sinensis* (1,2 and 3) regarding constituents of medicinal significance, pharmacological activities and its dietary usages are hereby mentioned: Since ages, *C. sinensis* has been regarded as panacea of life, imparting youth, vigour and longevity. Other medicinally important functions include–

(a.) Antitumour and anticancerous Property

Cordyceps can be use as a source of new anti-cancer drugs. *Cordyceps* is currently being recommended and used by a growing number of doctors worldwide as adjunct to chemotherapy, radiation and other conventional and traditional cancer treatments. It has show remarkable progress in not only inhibiting the growth of and in some cases even dissolving certain types of tumours, but also as a means by which the immune system and indeed the body in general may be kept strong and vital as it is being devastated by the effects of chemotherapy and radiation treatment (**Nakamura *et al.*, 2003**).

1. Constituents for medicinal significance of *Cordyceps sinensis*

S.No.	Component	Importance	Reference
1.	Cordycepin	Anti-tumour, Inhibition of RNA/DNA synthesis, suppression of viral replication (Anti-HIV) Antimalarial activity, Regulates homeostatic function Anti-leukemia activity	Penman and Rosbach (1970) Trigg *et al.*(1971) Mueller *et al.*(1991) Kuo *et al.*(1994) Miller(2005) Ng and Wang (2005) Tsai *et al.*(2010) Lui *et al.*(2007)
2.	Adenosine	Anti-inflammatory effect Control of Blood flow Prevention of cardiac arrhythmias	Berne(1980) Ding(1987) Pelleg and Porter(1990)
3.	Amino acids, zinc, vitamins & trace elements	Combats sexual dysfunction	Yang *et al.* (1985)
4.	Polysaccharides	Pharmacological activity, Inhibition of lipid peroxidation, prevention of hemolysis and inhibition of tumours, Anti-oxidationactivity, Immunomodulator and Antitumor property	Li, S.P. *et al.*(2001a) Li, S.P. *et al.*(2003) Yamaguchi *et al.*(2000) Guan and Li (2010) Sheng *et al.*(2011)
5.	Ergosterol	Anti-tumour and immunomodulatory effect	Ng and Wang(2005)
6.	Cordyglucans	Anti-tumour activity	Wu *et al.*(2005)
7.	Ergosta-4,6,8(14)22-tetraen-3-one(Ergone)	Cytotoxic Activtity (Cancer Treatment)	Ying *et al.*(2011)

2. Important pharmacological activities of *Cordyceps sinensis*

S.No.	Pharmacological Activity.	References
1.	Anti-asthmatic effect and anti-cancer agent	Huang (1993) Rao *et al.*(2007) Sun *et al.*(2010)
2.	Modulate immune responses	Kuo *et al.* (1996)
3.	Enhance hepatic energy	Manabe *et al.*(1996)
4.	Promote the secretion of adrenal Hormones	Wang *et al.*(1998)
5.	Regulating blood pressure (high or low blood pressue), Anti-aging, lowering raised blood lipid levels, Strengthening the body's immunity	Zhu *et al.*(1998a) Halpern (1999) Mizuno (1999) Francia *et al.*(1999)
6.	Inhibit the growth of tumour cells	Bok *et al.* (1999)
7.	Possess hypotensive and vasorelaxant activities	Chiou *et al.*(2000)
8.	Replenishment of body health	Li, S.P *et al.* (2001b) Li, S.P. *et al.*(2002)
9.	Anti-oxidation activity	Li, S.P *et al.*(2001a) Li, S.P *et al.*(2003) Xun *et al.*(2008) Liang *et al.*(2009) Wu *et al.*(2010)
10.	Alleviates fasting hyperglycaemia and Immunoregulatory activity.	Lin *et al.*(2002)
11.	Anti-tumour activity and stimulating the immune system.	Li, S.P *et al.*(2003) Wu *et al.*(2007) Park *et al.*(2008) Kawanishi *et al.*(2010)
12.	Anti-apoptotic property	Buenz *et al.*(2004)
13.	Enhancement on sexual performance and the restitution of impairment in sexual function	Huang *et al.*(2004)
14.	Reduce fatigue phlegm and stops haemorrhages. Improves the respiratory function, Improves the functioning of the heart, Improves stamina and athletic performance.	Miller (2005)
15.	Anti-inflammatory property	Rao *et al.*(2007)
16.	Hypoglycemic and Hypocholesterolemic activity	Xiao and Zhong (2007)
17.	Immunomodulator Property	Yarnell and Abascal(2008) Xiao *et al.*(2010)
18.	Improves pulmonary function and treat respiratory disease	Yue *et al.*(2008)
19.	Antidepressant like activity	Guo *et al.*(2010)
20.	Improves male reproductive dysfunction	Chen and Huang (2010)

3. Dietary uses of *Cordyceps sinensis* in Medicinal Dishes

S.No	Mode of Consumption	Medicinal value	References
1.	*Cordyceps* boiled with pork	Cures opium addiction, poisoning, Jaundice and tuberculosis	Gist (1918)
2.	*Cordyceps* cooked with duck	Potency of *Cordyceps* increased	Tiera (1998)
3.	*Cordyceps* cooked with chicken or duck soup	Used for the treatment of respiratory diseases, renal dysfunction, hyperlipidemia and hyperglycemia	Zhu *et al.(*1998b)
4.	Combination of *C. sinensis* with rhizome of *Dactylorhiza hatagirea* (D. Don), honey and cow's milk	Used for a tonic and aphrodisiac	Lama *et al.*(2001)
5.	*Cordyceps* mixed with alcohol or traditional green tea	Used for vitality and to cure stomach ailments	Garbyal *et al.*(2004)
6.	Combination with daily dosage one dried *C. sinensis* with half litre of milk and two teaspoons of ghee for a week	Used as a tonic and used for the sexual stimulant	Devkota(2006)

Its secondary effects on immune function help the body to more efficiently manage its immune resources while undergoing the stresses of the attack by cancer (**Shin *et al.*, 2003**) allowing it to recognize, eradicate and prevent abnormalities and disease, both at the local and the systemic level (**Koh *et al.*, 2002**). *Cordyceps sinensis* is found to have anti-leukemia activities (**Lui *et al.*, 2007**) and ameliorate suppressive effects of chemotherapy on bone marrow function as a model for cancer treatment (**Liu *et al*., 2008**)

(b.) Immunomodulating Property

Cordyceps sinensis can both suppress and enhance various aspects of the immune system, known as immunomodulators (**Yarnell and Abascal, 2008; Xiao *et al.*, 2010**). When Cordyceps is given to a patient in an immune-deficient state, such as cancer, hepatitis or HIV infection, the number and activity of the white blood cells increase. Conversely, if the same Cordyceps is given to someone in a hyper-immune state such as is found in Lupus, Lymphoma or Rheumatoid arthritis, the number and activity of the white blood cells drop, while the red blood cells often increase in number. The mechanism appears to be in the differentiation phase of blood cell production. Cordyceps effects leukemia cells maturing (**Chen *et al*., 1997**). This immunomodulation-at-the-differentiation level is like nature's smart bomb against disease (**Holliday and cleaver, 2004**).

(c.) Hypoglycemic effect

Cordyceps has been shown to help both diabetics and alcoholics. The caterpillar fungus is found to lower the blood sugar levels by the conservation of hepatic glycogen and improving glucose metabolism (**Zhao *et al.*, 2002**). *Cordyceps* has been tested in a number of animal and human trials for the potential as a blood sugar regulation agent, and it has performed very well in this roll indeed. It is efficient in lowering blood sugar levels in genetically diabetic animals and in those with chemically induced diabetes. It increases insulin sensitivity (**Balon *et al.*, 2002**) and also the liver's output of the glucose regulating enzymes, glucokinase and hexokinase. In short, it appears that, *Cordyceps* can be useful in the control of the diabetic patient, either as a single agent or in conjunction with other drugs (**Holliday and cleaver, 2004**).

(d) Improvement in Kidney Functioning

Cordyceps sinensis extract might be one novel therapeutic drug for chronic kidney diseases (**Song *et al.*, 2010**). Traditional views of the Cordyceps mushroom held that its consumption strengthened the Kidneys. C. sinensis has been found to accelerate the regeneration of tubular cells, protect the sodium pump activity of tubular cells and also reduces the content of calcium in certain tissues (**Li *et al*., 1996; Wang *et al.*, 1998**). It also improves disease conditions in various animal and human clinical trials with renal failure (**Zhen, 1992**), renal insufficiency (**Cheng, 1992; Guan *et al*., 1992**), mesangial nephropathy (**Lin, 1999**) and nephrotoxicity (**Zhao, 1993**).

(e.) Treatment of Respiratory Disorders

The traditional Chinese medicine *Cordyceps sinensis* (**Marchbank *et al*., 2011**) improves pulmonary function and is used to treat respiratory disease (**Yue *et al*., 2008**). *C. sinensis* has proved to be highly useful in alleviating other symptoms of several respiratory illnesses such as chronic bronchitis, etc. (**Kuo *et al.*, 2001**). Much of its reputation for protecting the lungs is believed to come from its ability to promote enhanced oxygen utilization efficacy. Such efficacy alludes to the use of *Cordyceps* as an effective treatment for Bronchitis, Asthma, and Chronic Obstructive Pulmonary Disease (COPD). Extracts of *C. sinensis* have been shown to inhibit tracheal contractions, especially important for asthma patients. In addition, its anti-inflammatory properties bring further relief to asthma patient (**Halpern, 1999**).

(f.) Improvement in Heart Functioning

The *Cordyceps* have the ability to stabilize the heart beats and correct heart arrhythmias. *Cordyceps* has been used traditionally for heart disease and stroke patients.

(g.) In Liver Disorders

Cordyceps is commonly used as an adjunct in the treatment of chronic hepatitis B and C. In one study, *Cordyceps* extract was used in combination with several other medicinal mushroom extracts as an adjunct to lamivudine for the treatment of hepatitis B. In this study, the group receiving the *Cordyceps* and other medicinal mushroom extracts had a much better outcome in a shorter period of time than the control group who received only the lamivudine (**Wang *et al.*, 2002**).

(h.) Hypercholesterolemia

Hypercholesterolemia is not a disease in true sense but is a clear indicator of dysfunction of the metabolic system and indicates high risk of cardiovascular attack. Studies have demonstrated that *C. sinensis* helps in lowering the total cholesterol level and also the level of triglycerides (**Geng, 1985 and Shao, 1985**). It also helps to increase the ratio of HDL-cholesterol (good cholesterol) to LDL cholesterol (bad cholesterol). The exact mechanism of lowering of cholesterol levels has yet to be deciphered. It might be probably by enhancing liver function or through blood sugar stabilization (**Singh *et al.*, 2007**).

(i.) Reduction of Fatigue

Cordyceps is a remedy for weakness and fatigue and is often used as an overall rejuvenator for increased energy while recovering from serious illness (**Holliday and Cleaver, 2004**). It also improves shortness of breath and reduces fatigue in patients suffering from chronic heart failure. It was thus, used by competitive athletes in the treatment of fatigue and weakness, and to improve endurance and increase energy levels (**Liu *et al.*, 1997**). The story related to *Cordyceps* that Goats and Yaks grazing on some sort of a small, brown grass-like mushroom, growing from the head of a caterpillar in the high mountains of Tibet and Nepal, would become frisky and start chasing the other goats and yaks around with lustful intent (**Holliday and Cleaver, 2004**).

(j.) Uses against Male/Female Sexual Dysfunction

Cordyceps has been used for centuries in Traditional Chinese Medicine to treat male and female sexual dysfunction (**Chen and Huang, 2010**), such as hypolibidinism and impotence. Preclinical data on the effects of *C. sinensis* on mice showed

sex-steroid-like effects. Human clinical trials have demonstrated similarly the effectiveness of *Cordyceps* in combating decreased sex-drive. *Cordyceps* was clearly indicated as a therapeutic agent in treating hypolibidenism and other sexual malfunction in both men and women (**Holliday and cleaver, 2004**).

(k.) Protection against Free Radical Damage

C. sinensis has powerful antioxidant properties and thus, can protect against the damages caused by free radicals (**Yamaguchi *et al.*, 2000; Li *et al.*, 2001b**) and hence acts as an anti-ageing agent (**Chen and Zhang, 1987**).

(l.) Made Human Organ Transplants Possible

Cyclosporin is an antifungal drug developed from *Tolypocladium inflatum*, which is the asexual stage of *Cordyceps*. It was quickly realized that when this drug was used, the patients did not have as much of a tendency to reject their new organs. This appears to be a down-regulation of the immune system or perhaps the cyclosporin is acting somehow as an anti-recognition factor. This is virtually the only use of cyclosporin today, as an anti-rejection drug for transplants patients (**Holliday and cleaver, 2004**).

REFERENCES

Arora R.K., Singh, N. and Singh, R.P. 2013. Characterization of an entomophagous medicinal fungus Cordyceps sinensis (Berk.) Sacc. of Uttarakhand, India. The Bioscan. 8(1):195-200.

Arora, R.K. 2008. Collection, Isolation and Characterization of Caterpillar Mushroom-Cordyceps sinensis (Berk.)Sacc. Of Uttarakhand. PhD Thesis, Govind Ballabh Pant University of Agriculture and Technology, Uttarakhand, India.160pp.

Arora, R.K. and Singh, R.P. 2009a. Biochemical characterization of caterpillar mushroom(Cordyceps sinensis). *Mushroom Research*, 18(1):39-41.

Arora, R.K. and Singh, R.P. 2009b. Effect of nutritional sources on mycelial growth of Caterpillar mushroom Cordyceps sinensis(Berk.) Sacc. *Journal of Mycology and Plant Pathology*, 39(1): 114-117.

Arora, R.K., Singh, R.P. and Guru, S.K. 2008. Determination of bio-active compounds in medicinal mushroom, Cordyceps sinensis. *Mushroom Research,* 17(2):61-66.

Balon, T.W., Jasman, A.P. and Zhu, J.S. 2002. A fermentation product of Cordyceps sinensis increases whole-body insulin sensitivity in rats. *Journal of Alternate and Complementary Medicine*, 8:315-323.

Berne, R.M.1980. The role of adenosine in the regulation of coronary blood flow. *Circular Research,* 47:807-813.

Bok, J.W., Lermer, L., Chilton, J., Klingeman, H.G. and Towers, G.H.1999. Antitumor sterols from the mycelia of Cordyceps sinensis. *Phytochemistry,* 51(7): 891-898.

Buenz, E.J., Weaver, J.C., Bauer, B.A., Chalpin, S.D. and Badley, A.D. 2004.*Cordyceps sinensis* extracts do not prevent Fas-receptor and hydrogen peroxide-induced T-cell apoptosis. *Journal of Ethnopharmacology*, 90(1):57-62.

Chatterjee, R., Srinivasan, K.S. and Maiti, P.C.1957. Cordyceps sinensis: Structure of Cordycepic acid. *J. Am. Pharm. Assoc.,* 46:114-118.

Chen, K. and Zhang, W. 1987. Advances on anti-aging herbal medicines in China. *Abstracts of Chinese Medicines*, 1: 309-330.

Chen, S.J., Yin, D.H., Zhong, G.Y. and Huang, T.F. 2002b. Study on the biology of adult parasite of Cordyceps sinensis, Hepialus biruensis. In: Zhongguo Zhong Yao Za Zhi. 27(12): 893-895.

Chen, Y.C. and Huang, B.M. 2010. Regulatory mechanisms of Cordyceps sinensis on steroidogenesis in MA-10 mouse Leydig tumor cells. *Bioscience, Biotechnology and Biochemistry,* 74(9):1855-1859.

Chen, Y.J., Shiao, M.S., Lee, S.S. and Wang, S.Y. 1997. Effect of Cordyceps sinensis on the proliferation and differentiation of human leukemic U937 cells. *Life Sciences,* 60:2349-2359.

Chen, Y.Q., Wang, N., Zhou, H. and Qu, L.H.2002a.Differentiation of medicinal Cordyceps species by rDNA 18S sequence analysis. *Planta Medica,* 68(7): 635-639.

Cheng, Q. 1992.Effect of Cordyceps sinensis on cellular immunity in rats with chronic renal insufficiency, Chung Hua I. Hsueh Tsa Chih.(Taipei). 72: 27-29.

Chiou, W.F., Chang, P.C., Chou, C.J. and Chen, C.F.2000. Protein constituent contributes to the hypotensive and vasorelaxant activities of *Cordyceps sinensis*. *Life Sci.,* 66(14):1369-1376.

Cunnigham, K.G., Hutchinson, S.A., Manson, W. and Spring, F.S. 1951.Cordycepin-A metabolic product from cultures of Cordyceps militaris (Linn.). Part 1, Isolation and characterization. *J. Chem. Soc.*, pp.2299-3000.

Devkota, S.2006. Yarsagumba [Cordyceps sinensis (Berk.) Sacc.] Traditional Utilization in Dolpa District, Western Nepal. Our Nature.4:48-52.

Ding, G.1987. Anti-arrhythmia agents in traditional Chinese medicines. *Abstracts of Chinese Medicines,* I:287-308.

Dong, C.H. and Yao, Y.J.2008. In vitro evaluation of antioxidant activities of aqueous extracts from natural and cultured mycelia of Cordyceps sinensis. *LWT Food Science and Technology*, 41(4):669-677.

Francia, C., Rapior, S., Courte cecuisse, R. and Siroux, Y.1999. Current research findings on the effects of selected mushrooms on cardiovascular diseases. *International Journal of Medicinal Mushrooms*, 1:169-172.

Garbyal, S.S., Aggarwal, K.K. and Babu, C.R.2004. Impact of Cordyceps sinensis in the rural economy of interior villages of Dharchula sub-division of Kumaon Himalayas and its implications in the society. *Indian Journal of Traditional Knowledge*, 3(2):182-186.

Geng, S.1985.Treatment of Hyperlipidemia with Cultivated Cordyceps-A Double Blind, Randomized Placebo Control Trial. *Chinese Journal of Internal Medicine*, 5:652.

Gist, G.N.1918. Notes on Cordyceps sinensis. *Mycology Notes.* 54:767-768.

Guan, J. and Li, S.P.2010.Discrimination of polysaccharides from traditional Chinese medicines using saccharide mapping - enzymatic digestion followed by chromatographic analysis. *Journal of Pharmaceutical and Biomedical Analysis*, 51(3):590-598.

Guan, Y.J., Hu, G., Hou, M.., Jiang, H., Wang, X. and Zhang,C. 1992.Effect of Cordyceps sinensis on T-lymphocyte subsets in Chronic renal failure, Chinese *Journal of Integrated Medicine*, 323(12):338-339.

Guo, J.Y., Han, C.C. and Liu, Y.M.2010. A contemporary treatment approach to both diabetes and depression by Cordyceps sinensis, rich in vanadium. *Evidence based Complementary and Alternative Medicine*, 7(3): 387-389.

Gwangpo, K.2000a. Characteristics of Cordyceps species. hits: 539. www.mushworld.com.

Halpern, G.M.1999. Cordyceps-China's Healing Mushroom. Avery Publishing Group. NewYork, USA.pp.16.

Harsahay, M., Mohsin, M., Pandey, H.K., Negi, P.S. and Ahmed, Z.2010. Estimation of cordycepin by improved HPLC method in the natural and cultured mycelia of high medicinal value Himalayan entomogenous fungus Cordyceps sinensis, *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 9(10): 1598-1603.

Hobbs, C.L.1986. Medicinal Mushrooms. An exploration of tradition, healing and culture.pp. 81-86.

Holliday, J and Cleaver, M.2004. On the Trail of the Yak: Ancient Cordyceps in the modern world. www.mush world.com/medicine.

Holliday, J.C. and Cleaver, M. 2008. Medicinal value of the caterpillar fungi species of the genus Cordyceps (Fr.) Link (Ascomycetes), A review. International Journal of Medicinal Mushrooms. 10(3):219-234.

Hong, Z. and Li, Y.1990. Immuno-pharmacological functions of Cordyceps. *Chinese Journal of International Trade and Western Medicine*, 10:570-571.

Hsu, T.H.1999. Health benefits of Cordyceps related species. J. Chin. Soc. Tradit. Vet. Soc. 3:48-61.

Huang, K.C.1993.The Pharmacology of Chinese Herbs. *CRC Press, Boca Raton*, Florida.pp., 207-208.

Huang, L.F., Liang, Y.Z., Guo, F.Q., Zhou, Z.F. and Cheng, B.M.2003. Simultaneous separation and determination of active components in Cordyceps sinensis and Cordyceps militaris by LE/ESI-MS, *J. Pharma Biomed. Ana.* 33:1155-62.

Hye,Y.L. 1999. The life of Caterpillar fungi and its Cultivation. hits: 383. website:www.mushworld.com.

Illana, E.C.2007. Cordyceps sinensis - a fungi used in the Chinese traditional medicine. Revista Iberoamericana de Micologia, 24(4):259-262.

Jason, E.B.2005. Medicinal mushrooms. Alternative and complementary Therapies. 11(3) :141-145.

Jiang, Y. and Yao, Y.J.2002. Names related to Cordyceps Sinensis anamorph. Mycotaxon. October-December. 84: 245-254.

Jing, K.Y., Wenkian, W.Q., Lin L and Jian, Y.W.2011. Physiochemical properties and antitumor activities of two alpha-glucans isolated from hot water and alkaline extracts of Cordyceps (Cs-HK1) fungal mycelia. *Carbohydrate Polymers*, 85(4): 753-758.

Jones.1997. An ancient Chinese secret promotes longevity and endurance. *Healthy and Natural Journal,* 3(3): 90-93.

Kawanishi, T., Ikeda, D.Y. and Nagayama, A.2010. Effects of two basidiomycetes species on interleukin 1 and interleukin 2 production by macrophage and T cell lines. *Immunobiology*, 215(7):516-520.

Kobayasi, Y.1941. The genus Cordyceps and its allies. Sci. Rep. Tokyo Bunrika Daigaku. Section B-5. 53-260.

Koh, J.H., Yu, K.W., Suh, H.J., Choi, Y.M. and Ahn, T.S.2002. Activation of macrophages and the intestinal immune system by an orally administered decoction from cultured mycelia of Cordyceps sinensis, Biosci. Biotechnol. *Biochem.,* 66(2):407-411.

Kuo, Y.C., Lin, C.Y., Tsai, W.J., Wu, C.L., Chen, C.F. and Shiao,M.S.1994.Growth inhibitors against tumor cells in *Cordyceps sinensis* other than cordycepin and polysaccharides. *Cancer Invest.* 12:611-615.

Kuo, Y.C., Tsai, W.J., Shiao, M.S., Chen, C.F. and Lin, Y.C.1996. *Cordyceps sinensis*, as an immunomodulatory agent. *Am. J. Chin. Med*., 24:111-125.

Kuo, Y.C., Tsai, W.J., Wang, J.Y., Chang, S.C., Lin, C.Y.2001.Regulation of bronchoalveolar lavage fluid cell function by the immunomodulatory agents from Cordyceps sinensis. *Life Science*, 68:1067-1082.

Lama, Y.C., Ghimirey, S.K. and Thomas, Y.A.2001. Medicinal plants of Dolpa: Amchis Knowledge and Conservation. WWF Nepal Program, Kathmandu.pp.56.

Lei, J.1992. Pharmacological study on Cordyceps sinensis (Berk.) Sacc. and ze-e Cordyceps. Chung Kuo Chung Yao Tsa Chih. 17(6):364-366.

Li, S.P., Zhao, K.J., Ji, Z.N., Song, Z.H., Dong, T.T.X., Lo, C.K., Cheung, J.K.H., Zhu, S.Q. and Tsim, K.W. 2003. A polysaccharide isolated from *Cordyceps sinensis*, a traditional Chinese medicine, protects PC12 cells against hydrogen peroxide-induced injury. *Life Science,* 73:2503-2513.

Li, L.S., Zheng, F. and Liu, Z.H. 1996. Experimental study on the effect of Cordyceps sinensis in ameliorating aminoglycoside induces nephrotoxicity. Chung Kuo Chung Hsi I Chieh Ho Tsa Chih. 16:733-737.

Li, S.P., Li, P., Dong, T.T. and Tsim, K.W.K. 2001b. Determination of nucleosides in natural Cordyceps sinensis and cultured Cordyceps mycelia by capillary electrophoresis. *Electrophoresis,* 22:144-150.

Li, S.P., Li, P., Dong, T.T. and Tsim, K.W.K.2001a.Anti-oxidation activity of different types of natural *Cordyceps sinensis* and cultured *Cordyceps* mycelia. *Phytomedicine,* 8:207-212.

Li, S.P., Su, Z.R., Dong, T.T.X. and Tsim, K.W.K.2002.The fruiting body and its caterpillar host of Cordyceps sinensis show close resemblance in main constituents and antioxidation activity. *Phytomedicine,* 9(4):319-324.

Liang, C.H., Huang, S.J., Tsai, S.Y., Lee, Y.L., Kuo, H.C., Wu, T.P., Jian, S.Y., Huang, W.L. and Mau, J.L. 2009. Antioxidant properties of novel solid-state fermented culinary-medicinal mushroom and fungi products. *International Journal of Medicinal Mushrooms,* 11(3):259-268.

Lin, C.Y. 1999. Inhibition of activated human mesangial cell proliferation by the natural product of Cordyceps sinensis (H1-A): an implication for treatment of IgA mesangial nephropathy. *J. Lab. Clin. Med.*, 133:55-63.

Lin, S., Lo, H. and Lin, C. 2002. Oral administration of Cordyceps does not affect lymphocyte subsets in STZ-induced diabetic rats. *Journal of Nutritional sciences*, 27(2):77-83.

Ling, J.Y., Sun, Y.J., Zhang, H. and Zhang, C.K. 2002. Measurement of cordycepin and adenosine in stroma of Cordyceps sp. by capillary zone electrophoresis (CZE). *J. Biosci. Bioeng.,* 94:371-374.

Liu, C., Xue, H.M., Xu, L.M., Zhao, P.Z., Zhang, L.B. and Tang, M.G. 1986. Treatment of 22 patients with post hepatic cirrhosis with a preparation of fermented mycelia of Cordyceps sinensis Shanghai. *J. Chinese Materia. Medica*, 6:30-31.

Liu, J., Yang, S., Yang, X., Chen, Z. and Li, J.1997. Anti-carcinogenic effect and hormonal effect of *Cordyceps militaris* Link. *Chung Kuo Chung Yao Tsa Chih*.(Chinese Journal). 22: 111-113.

Liu, W.C., Chuang, W.L., Tsai, M.L., Hong, J.H., McBride, W.H. and Chiang,C.S.2008. Cordyceps sinensis health supplement enhances recovery from taxol-induced leucopenia. *Experimental Biology and Medicine*, 233(4):447-455.

Lui, J.C.K., Wong, J.W.Y., Suen, Y.K., Kwok, T.T., Fung, K.P and Kong, SK. 2007. Cordycepin induced eryptosis in mouse erythrocytes through a Ca<ovid:sup>2+</ovid:sup>-dependent pathway without caspase-3 activation.

Mains, E.B. 1940. Cordyceps species from Michigan. Papers Michigan Academy of Science. 25:79-84.

Mains, E.B. 1957. Species of Cordyceps parasitic on Elaphomyces. Bul. Torrey. Bot. Club. 84:243-251.

Mains, E.B.1947. New and interesting species of Cordyceps. *Mycologia,* 39: 535-545.

Mains, E.B.1954. Species of Cordyceps on Spiders. Bull. Torrey. Bot. Club. 81: 492-500.

Manabe, N., Azuma, Y., Sugimoto, M., Uchio, K., Miyomoto, M., Taketomo, N., Tsuchita, H. and Miyomoto, H. 2000. Effect of mycelial extract of cultured Cordyceps sinensis on in vivo hepatic energy metabolism and blood flow in dietary anemic mice. *British Journal of Nutrition*, 83:197-204.

Manabe, N., Sugimoto, M., Azuma, Y., Taketomo, N., Yamashita, A.,Tsuboi, H., Tsunoo, A., Kinjo, N., Nian, L.H. and Miyamoto, H. 1996. Effect of the mycelial extract of cultured Cordyceps sinensis on in vivo hepatic energy metabolism in the mouse. *Japanese Journal Pharmacol.*, 70(1): 85-88.

Marchbank, T., Ojobo, E., Playford, C.J. and Playford, R.J. 2011. Reparative properties of the traditional Chinese medicine Cordyceps sinensis (Chinese caterpillar mushroom) using HT29 cell culture and rat gastric damage models of injury. *British Journal of Nutrition*, 105(9):1303-1310.

Massee, G.1895. A revision of the genus Cordyceps. Nn. Bot. 9:1-44.

Miller, R.A. 2005. Lab-grown. Cordyceps sinensis hybrid: A nano-processed Medicinal Mushroom that Really Delivers. Website:www.pharmaceuticalmushrooms.nwbotanicals.org.

Mizuha, Y., Yamamoto, H., Sato, T., Tsuji, M., Masuda, M., Uchida, M., Sakai, K., Taketani, Y., Yasutomo, K., Sasaki, H. and Takeda, E. 2007.Water extract of Cordyceps sinensis inhibits the RANKL-induced osteoclast diffentiation. *BioFactors,* 30(2):105-116.

Mizuno, T., Saito, H., Nishitoba, T. and Kawagishi, H. 1995. Antitumor active substances from mushrooms. *International Journal of Food Reviews,* 111: 23-61.

Nakamura. K., Konoha, K., Yamaguchi, Y., Kagota, S., Shinozuka, K. and Kunitomo, M. 2003. Combined effects of *Cordyceps sinensis* and methotrexate on hematogenic lung metastasis in mice. *Receptors Channels,* 9(5):329-334.

Negi, C.S. 2007. Changing face of polyculture in the Darma and Johaar valleys, Pithoragarh, Kumaun Himalayas. *International Journal of Sustainable Development and World Ecology*, 14(4): 428-436.

Negi, P.S. 2005. Systematics of mushrooms of Almora and Pithoragarh districts. Ph.D. Thesis, Deptt. of Botany, Kumaun University, Almora.(Uttarakhand),India pp.162.

Ng, T.B. and Wang, H.X. 2005. Pharmacological actions of *Cordyceps*, a prized folk medicine. *Journal of Pharmacy and Pharmacology,* 57(12):1509-1519.

Park, D.K., Choi, W.S., Park, P.J., Kim, E.K., Jeong, Y.J., Choi, S.Y., Yamada, K., Kim, J.D. and Lim, B.O. 2008. Immunoglobulin and cytokine production from mesenteric lymph node lymphocytes is regulated by extracts of *Cordyceps sinensis* in C57Bl/6N mice. *Journal of Medicinal Food*, 11(4): 784-788.

Pelleg, A. and Porter, R.S.1990. The pharmacology of Adenosine. *Pharmacotherapy*. 10:157-174.

Petch, T.1921. Fungi parasitic on scale insects. Brit. Myc. Soc. Trans. 7:18-40.

Rao, Y.K., Fang, S.H. and Tzeng, Y.M.2007. Evaluation of the anti-inflammatory and anti-proliferation tumoral cells activities of Antrodia camphorata, *Cordyceps sinensis* and *Cinnamomum osmophloeum* bark extracts. *Journal of Ethnopharmacology*, 114(1):78-85.

Rogers, D.P.1954. The genus Cordyceps and Friese's Observation. *Mycologia,* 46: 248-253.

Saccardo, P.A.1883. Cordyceps. *Syll Fungi.,* 2:566-578.

Shao, G.1985. Treatment of Hyperlipidemia with Cultivated Cordyceps-A double blind, randomized placebo control trial. Chung Hsi I Chieh Ho Tsa Chih. 5:652-665.

Sharma, S. 2004. Trade of Cordyceps sinensis from high altitudes of the Indian Himalaya: conservation and biotechnological priorities. *Current Science*, 86 (12): 1614-1619.

Sheng, L., Chen, J.P., Li, J. and Zhang, W.Y.2011. An exopolysaccharide from cultivated *Cordyceps sinensis* and its effects on cytokine expressions of immunocytes, *Applied Biochemistry and Biotechnology*, 163(5):669-678.

Shi, Z., Huijuan, P., Leifa, F., Guoying, L., Yongzhi, W., Binod, P., Pandey, A. and Soccol, C.R. 2009. Advances in research of polysaccharides in Cordyceps species. *Food Technology and Biotechnology*, 47(3): 304-312.

Shin, K.H., Lim, S.S., Lee, S., Lee, Y.S., Jung, S.H. and Cho, S.Y. 2003. Anti-tumour and immuno-stimulating activities of the fruiting bodies of Paecilomyces japonica, a new type of Cordyceps spp. *Phytother Res.,* 17(7): 830-833.

Singh, R.P., Pachauri, V., Verma, R.C. and Mishra, K.K.2008. Caterpillar fungus (Cordyceps sinensis) - *A Review. J. Eco-friendly Agric*., 3(1):1-15.

Singh, R.P., Verma, R.C., Arora, R.K., Mishra. K.K., Bhanu, C. 2007. Medicinal mushrooms of Uttaranchal with particular reference to Ganoderma, Auricularia and Cordyceps sinensis, Mushroom Biology and Biotechnology Proc, ICMBB eds. RD Rai, SK Singh, MC Yadav and RP Tewari. pp.321-324.

Song, L.Q., Yu, S.M., Ma, X.P. and Jin, L.X. 2010. The protective effects of Cordyceps sinensis extract on extracellular matrix accumulation of glomerular sclerosis in rats. *African Journal of Pharmacy and Pharmacology*, 4(7):471-478.

Sprecher, M. and Sprinson, D.B.1963. A reinvestigation of the structure of Cordycepic acid. *Journal of Organic Chemistry*, 28:2490-2491.

Steinkraus, D.C. and Whitefield, J.B.1994. Chinese caterpillar fungus and world record runners. *Am. Entomol.,* 40:235-239.

Sun, W., Yu, J., Shi, Y.M., Zhang, H., Wang, Y. and Wu, B.B. 2010. Effects of *Cordyceps* extract on cytokines and transcription factors in peripheral blood mononuclear cells of asthmatic children during remission stage. *Journal of Chinese Integrative Medicine*, 8(4): 341-346.

Tiera, M.1998. The Way of Chinese Herbs, (Pocket Books), pp.255.

Trigg, P., Gutteridge, W.E. and Willaimson, J. 1971. The effect of cordycepin on malarial parasites. *Trans R. Soc. Trop. Med. Hyg.* 65:514-520.

Tsai, Y.J., Lin, L.C. and Tsai, T.H. 2010. Pharmacokinetics of adenosine and cordycepin, a bioactive constituent of *Cordyceps sinensis* in rat. *Journal of Agricultural and Food Chemistry*, 58(8): 4638-4643.

Wang, R., Xie, J., Ji, P., Li, S., Zhan, H., Xia, J., Sun, H., Lei, L., Yu, J., Wang, Y. and Holliday, J. 2002. Clinical Trial report on Chronic Hepatitis treatment using Immune Assist brand mushroom extract mixture in conjunction with the drug Lamivudine http://alohamedicinals.com/ Hep_B_Study2.htm.

Wang, S.M., Lee, L.J., Lin, W.W. and Chang, C.M. 1998. Effects of a water-soluble extract of Cordyceps sinensis on steroidogenesis and capsular morphology of lipid droplets in cultured rat adrenocortical cells. *Journal of Cell Biochemistry*, 69: 483-489.

Wang, S.Y. and Shiao, M.S. 2000. Pharmacological functions of Chinese Medicinal Fungus *Cordyceps sinensis* and related species. *Journal of Food and Drug Analysis*, 8(4).84-88.

Weckerle, C.S., Yang, Y.P., Huber, F.K. and Li, Q. H. 2010. People, money, and protected areas: the collection of the caterpillar mushroom Ophiocordyceps sinensis in the Baima Xueshan Nature Reserve, Southwest China. *Biodiversity and Conservation,* 19(9): 2685-2698.

Wei, Q., Ya, B.Y., Pu,J.W. and Wei, L.2011. The co-effect of Cordyceps sinensis and strontium on osteoporosis in ovariectomized osteopenic rats. *Biological Trace Element Research*, 141(1-3): 216-223.

Winkler, D. 2004. Yarsta Gunbu-Cordyceps sinensis, Economy, Ecology and Ethno-Mycology of a Fungus Endemic to the Tibetan Plateau (Eds. A. Boesi and F. Cardi).Wildlife and plants in traditional and modern Tibet: Conceptions, *Exploitation and Conservation,* 34(1/2).

Winkler, D. 2008. Yartsa gunbu (Cordyceps sinensis) and the fungal commodification of Tibet's rural economy. Economic Botany. 62(3): 291-305.

Wu, J.Y., Zhang, Q.X. and Leung, P, H. 2007. Inhibitory effects of ethyl acetate extract of Cordyceps sinensis mycelium on various cancer cells in culture and B16 melanoma in C57BL/6 mice. *Phytomedicine*, 14(1):43-49.

Wu, S.H., Zhang, X.J., Zhang, P. and Chen, Z.H. 2010. Antioxidant activities of the methanolic extracts of four species of Ascomycetes. *Mycosystema,* 29(1):113-118.

Wu, Y., Ishurd, O., Sun, C.R. and Pan, Y.J. 2005. Structure analysis and antitumor activity of (1->3) - beta-D-glucans (Cordyglucans) from the mycelia of *Cordyceps sinensis*. *Planta Medica*, 71(4): 381-384.

Xiao, G., Miyazato, A., Abe, Y., Zhang, T.T., Nakamura, K. 2010. Activation of myeloid dendritic cells by deoxynucleic acids from Cordyceps sinensis via a Toll-like receptor 9-dependent pathway. *Cellular Immunology*, 263(2): 241-250.

Xiao, J.H. and Zhong, J.J. 2007. Secondary metabolites from *Cordyceps* species and their antitumor activity studies. *Recent Patents on Biotechnology,* 1(2):123-137

Xiao, Y.Q., Liu, J.M. and Tu, Y.Y. 1983. Studies on chemical constituents in Cordyceps sinensis. *I. Bull. Chin. Mat. Med.*, 8:32-33.

Xu, W.H., Xuc, Z. and Ma, J.M. 1988b. Water-soluble constituents in Cordyceps sinensis. *I. Bull. Chin. Mat. Med.,* 8: 32-33.

Xun, C.Q., Shen, N.Y., Li, B.L., Zhang, Y.H., Wang, F., Yang, Y.X., Shi, X., Schafermyer, K., Brown, S.A. and Thompson, J.S. 2008. Radiation mitigation effect of cultured mushroom fungus *Hirsutella sinensis* (Corimmune) isolated from a Chinese/Tibetian herbal preparation *Cordyceps sinensis*, *International Journal of Radiation Biology*, 84(2):139-149.

Yamaguchi, Y., Kagota, S., Nakamura, K., Shinozuka, K. and Kunitomo, M. 2000. Antioxidant activity of the extracts from fruiting bodies of cultured Cordyceps sinensis. Phytother. Res., 14:647-649.

Yang, H.D., Ma, Z.L., Sun, T.Q., Zhang, X.C. and Cai, J.G. 1985. Comparative study on the chemical constituents between xiangbangchongcao *(Cordyceps barnessi*) and *Cordyceps (Cordyceps sinensis).Chinese Traditional Herbal Drugs*.16:194-195.

Yarnell, E. and Abascal, K. 2008. Lupus erythematosus and herbal medicine. Alternative and Complementary Therapies, 14(1): 9-12.

Yuan, J.P., Wang, J.H., Liu, X., Kuang, H.C. and Zhao, S.Y. 2007. Simultaneous determination of free ergosterol and ergosteryl esters in *Cordyceps sinensis* by HPLC. *Food Chemistry,* 105(4):1755-1759.

Yue, G., Lau, B., Fung, K., Leung, P. and Ko, W. 2008. Effects of Cordyceps sinensis, Cordyceps miltaras and their isolated compounds on ion transport in Calu-3 human airway epithelial cells. *Journal of Ethnopharmacology*, 117(1):92-101.

Zhao, C.S., Yin, W.T., Wang, J.Y., Zhang, Y., Yu, H., Cooper, R., Smidt, C. and Zhu, J.S. 2002. Cordyceps Cs-4 improves glucose metabolism and increases insulin sensitivity in normal rats. *J. Altern. Complement. Med.,* 8(4):403-405.

Zhao, X. 1993.Cordyceps sinensis in protection of the kidney from cyclosporine A nephrotoxicity, Chung Hua I Hsueh Tsa Chih. 73:410-441.

Zhen, F.1992. Mechanisms and therapeutic effect of Cordyceps sinensis (CS) on aminoglycoside induced acute renal failure (ARF) in rats.Chung Kuo Chung Hsi I Chieh Ho Tsa Chih. 12:288-329.

Zhen, Y.Z., Chuan, L.S., Yue, R.Z., Chang, M.Z, Jia, P.Z., An, J.L. and Yong, M.Z. 2011. The purification and antioxidative activities in D-galactose-induced aging mice of a water-soluble polysaccharide from Cordyceps gunnii (berk.) Berk. Mycelium. *Journal of Food Biochemistry*, 35(1):303-322.

Zhong, X., Peng, Q.Y., Qi, L.L., Lei, W. and Liu, X. 2010. rDNA-targeted PCR primers and FISH probe in the detection of Ophiocordyceps sinensis hyphae and conidia. *Journal of Microbiological Methods*, 83(2): 188-193.

Zhou, L.1990. Short term curative effect of cultured *Cordyceps sinensis* (Berk) Sacc. Mycelia in Chronic Hepatitis B. *Chang Kuo Chung Yao Tsa Chih*.(Chinese Journal)19:53-55.

Zhu, J.S., Halpern, G.M. and Jones, K. 1998b. The Scientific Rediscovery of an Ancient Chinese Herbal Medicine: Cordyceps sinensis Part 11. *Journal of Alternative and Complementary Medicine,* 4(4):429-457.

Zhu, J.S., Halpern, G.M. and Jones, K.1998a. The Scientific Rediscovery of an ancient Chinese Herbal Medicine: Cordyceps sinensis Part-1. *Journal of Alternative and Complementary Medicine*, 4(3):289-303.

****