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## Sportsmen's energy package *Cordyceps sinensis*: Medicinal importance and responsible phytochemical constituents

**Yogesh Chandra Joshi, Mukesh Chandra Joshi, Vivek Chopra, Rakesh Kumar Joshi, Rajni Kant Sharma and Vikrant Kumar**

**Abstract**

Yarsagumba (*Cordyceps sinensis*) is one of the world rarest fungal species that parasites on the body of a caterpillar of a moth and found underground of alpine grass at high altitude. The *Cordyceps sinensis* is known as "summer plant and winter insect" or "half-caterpillar-half-mushroom". This fungus used for various medicinal purposes, caring diseases and specially used as a food product in China and south Asian countries. It contains various biologically active pharmacophores which helps to maintain the health and body. Reports say that, the regular use of *Cordyceps*, is very useful for sportsperson to maintain their body balance, endurance, strength, and to make healthy body weight etc. On the basis of scientific and manmade facts, we tried to summarise, why *Cordyceps* is recommended to sport person as a physical booster. It contains various bioactive pharmacophores including essential oil, which are medicinally important. Thus body always looks for such type of dietary supplements.

**Keywords:** Yarsagumba, *Cordyceps*, Physical endurance, Physical booster, Stamina, Phytochemical constituents

**1. Introduction**

Yarsagumba is one of the world rarest fungal species that parasitizes the body of a caterpillar of a moth [1]. This herb is found underground of alpine grass at high altitude (3000-5000 m) between the Himalayas of Indian, Chinese, Nepal, Bhutan and Tibetan Plateau. It is also named as Caterpillar fungus known as *Cordyceps sinensis* which is hosted by Thitarodes insect during its asexual cycle. Recent study proposed that the botanical name of Yarsagumba changed from *Cordyceps sinensis* to *Ophiocordyceps sinensis* [2]. The latin name *Cordyceps sinensis* means "summer plant and winter insect" so called the mysterious "half-caterpillar-half-mushroom". Before the rainy season begins, spores of the *Cordyceps* mushroom settled on the heads of caterpillars that lives underground. The fungus gets so much into the body of the caterpillars that it grows out through its head and drains all the energy from the insect and ultimately it dies (Fig. 1, [www.youtube.com/channel/UCII7KZhkaWBsVCEFKUMGDog](http://www.youtube.com/channel/UCII7KZhkaWBsVCEFKUMGDog)). The fungus takes 5-7 years for complete its life cycle. It is dark brown fructification and yellowish white stalk having small spikes. The size of the fungus is about 4 to 12 cm in length and 0.14 to 0.4 cm in girth. *Cordyceps* is known by different names Yarsagumba, Buti, Jivanbuti, caterpillar mushroom and *Cordyceps* while in China it is known as Dong Chong Xia Cao and in Tibet it is known as winter (yarsa) and summer (gumba) grass. It is also called Keera Jhar (insect herb) by the local Nepalese.

It has been used since ancient in China as a traditional medicine and in south Asian content for more than 3000 years [3]. Caterpillar fungus specially been used for its medicinal importance [4-12]. It is also used as food product in China and south Asian countries. It has traditionally been used for backache, blood production, impotence, to increase sperm production, chronic cough, asthma, improve shortness of breath anemia, improves blood circulation and regulates blood pressure, production of bone marrow, to remove tiredness, soreness of loins and knees, dizziness, tinnitus, to strengthen the immune system of tumor patients who have received radiotherapy, chemotherapy, anticancerous [4, 11, 12], in the treatment of deficiency syndrome caused by overstrain, to strengthen the immune system by attacking on virus and bacteria, anti-allergic, reduce triglycerides and cholesterol level, increases vitality and stamina, enhancing physical endurance and mental stability, controls liver, lung and kidney dysfunction, reduces

pains of loins and knees <sup>[13-17]</sup>. It is also used as traditional healer such as erectile dysfunction, malignant tumors, diabetes, female aphrodisia, bronchitis, asthma, cough and cold, jaundice, alcoholic hepatitis, anti-tussive and expectorant effects etc. It is also used as a natural Viagra or also known as Himalayan Herbal Viagra.

*Cordyceps* contains several biologically active pharmacophores such as sterols, alkaloids, polysaccharides, nucleosides, amino acids, inorganic elements, vitamins, fatty acids and other ketone, aldehydes, ether, and phenols etc. Thus human body always look for such type of dietary supplements which contains all the material in it. Thus, we can say *Cordyceps* must be responsible for its mode of action against human health hazards.



**Fig 1:** Caterpillar fungus

#### Scientific classification

Kingdom	:	Fungi
Subkingdom	:	Dikarya
Phylum	:	Ascomycota
Subphylum	:	Pezizomycotina
Class	:	Sordariomycetes
Subclass	:	Hypocreomycetidae
Order	:	Hypocreales
Family	:	Clavicipitaceae
Genus	:	<i>Cordyceps</i> Species

**Spp.** about 300 described species <sup>[18]</sup> some common are as follows:

- C. bassiana* (Bals.-Criv.)
- C. gunnii*
- C. militaris*
- C. ophioglossoides*
- C. sinensis*
- C. subsessilis* (Petch)
- C. unilateralis*

#### 2. Habitat, Ecology and Economy

*Cordyceps* is generally found in the alpine region of the Himalayas at the elevation >3000 m. *Cordyceps* mostly found above the snowline in Jumla, Dolpa, Kalikot, Baglung, Mustang, Humla, Rasuwa and Manang districts of Nepal and Ganzi, Lithang and high Himalayas of India, Tibet and Bhutan <sup>[19]</sup>. The suitable conditions are high altitude, low oxygen level and low temperature for *Cordyceps* cultivation. Most of Alpine rural population economically based on this cultivation in Nepal and Tibet. It has a very high trade value

that is transacted at more than twice the cost of gold by weight. For last couple of years, the trade of Yarsagumba is increasing and it has been regarded as an expensive life saving tonic. Yarsagumba is a remedy for headache, toothache or any many other diseases. Thousands of villagers particularly from Nepal and Tibet are risking their own lives to collect Yarsagumba from high mountains during May and August for making money.

#### 3. *Cordyceps* as a physical booster for sportsman

*Cordyceps* has been used to support good balance, strength, and a healthy body weight. It is also used widely and traditionally to increase the energy and enhance stamina in the human body. It has a positive effect on blood sugar and fat metabolism, which is important to boost the health, because fats and sugars are actively mobilized during activation of the stress response to supply the body with extra energy. Furthermore, the cell-protective and antioxidant activities of *Cordyceps* have been documented <sup>[6]</sup>. Traditional Chinese medicine practitioners also recommend the regular use of *Cordyceps* to strengthen the body <sup>[6, 20, 21]</sup>.

Daily dietary supplements are the best known to reducing the risk of disease, to maintain good health and to improve homeostasis. Thus research for complete package energy food is high in demands, which can be effective, nontoxic, antioxidant and ergogenic properties has gained attention. During the training of sportsperson, the individual is looking for large amount of physical and psychic energy. During this time numerous energetic and other substances are consumed by the sportsperson to retain their physical energy and strength <sup>[22-26]</sup>. Thus the individuals are looking for the complete package of energy and we know that giving individuals a complete package of energy substances through food is not possible therefore; nutrition specialists are facing lot of problems regarding this. For strengthened the body it has been scientifically proved that various food supplements are helpful in solving this problem <sup>[27]</sup>, and one of them is *Cordyceps*, which is gaining a lot of attention as a food supplement or a complete energy package for sportsmen's nutrition.

In 1993 World Championships in Athletics, the manager of a group of dominant Chinese female distance runners, announced that his athletes had been fed a soup of Yarsagumba and turtle blood. Daniel Winkler, an ecologist has done extensive research on this fungus, and explains in one of his articles that, "Among the wealthy and power in China," Yarsagumba, "has come to rival French champagne as a status symbol at dinner parties or as a prestigious gift." Researchers are working to raise the adaptive reserves of sportsmen functional system to ensure the positive result in the training outcome. Therefore, the important part is to investigations of the effects of *Cordyceps* (a food supplement used by sportsmen), on their blood haematological and biochemical indices of the individual sportsperson. Thus, it has been concluded that the effect of *Cordyceps* may contribute to improving the course of adaptation of elite sportsmen to physical loads, increasing the physical and functional capacity of their body, results in better sport results. Researchers studied the effect of *Cordyceps* in 28 sportsmen aged between 22–25 years. Members of the experimental group were administered *Cordyceps* in capsules, each containing 500 mg of dry fermented powder of the *Cordyceps sinensis*. *Cordyceps* was administered for 14 days (according to the following scheme: one capsule with breakfast and one with lunch for 4 days, one capsule three

times a day for 6 days, and one capsule four times a day for 4 days) which shows that no significant change in red blood corpuscles, mean red corpuscle volume, red corpuscle distribution area, mean corpuscular haemoglobin and its concentration in the blood and also there is no positive effect of *Cordyceps* on haemopoiesis. However during this, the positive changes in number of leukocyte and leukocyte formula were observed. The number of lymphocytes increased, and the percentage ratio between granulocytes and agranulocytes was levelled in the leucogram. Creatinine concentration, which statistically significantly increased over the experimental period on the background of lowered creatinekinase, uric acid and urea levels in the blood of the studied individuals, indicates the ergogenic effect of *Cordyceps* on the energetic system, physical and functional performance of the sportsmen's body [28]. Related study has been done by Meena *et al.* [29] in rat and observed that no significant change in organ weight and serological parameters, however, there was a significant increase in food intake, body weight gain and haematological parameters such as RBC, WBC, Hb and lymphocytes in treated group.

The traditional uses of *Cordyceps* in Sikkim, India, found that most of local folk healers/traditional healers use *Cordyceps* for the treatment of 21 ailments. One research group from China have reported that *Cordyceps* helps in lactate clearance and improved lactate energy metabolism within the cell of mice and allowing athletes greater anaerobic physical performance [30]. There are few other reports have been published regarding the curative effect of *Cordyceps* involving various experimental model and some clinical trials in volunteer athletes [31]. Clinical research has shown that *Cordyceps* increased cellular bio-energy ATP [32] by increase in useful energy and improves internal mechanism, which results more and more efficient utilization of oxygen [33].

Rossi *et al.* reported that a specific combination of fungal supplements can help to improve the performance of endurance in athletes. They studied the effects of a brief 3-month trial of two fungal supplements, *Ganoderma lucidum* and *Cordyceps sinensis* (3 capsules of *C. sinensis* and 2 capsules of *G. lucidum* per day), in ages between 30-40 years old, 7 healthy male volunteers, amateur cyclists participated in "Gran Fondo" cycling races. They reported the effects of fungal supplements on physical fitness of the athletes by monitoring and comparing the testosterone/cortisol ratio in the saliva and oxidative stress [DPPH (1, 1'-diphenyl-2-picrylhydrazyl) free radical scavenging activity] just before and after the physical activity [34, 35]. They observed a decrease of more than 30% in the testosterone/cortisol ratio after race compared to before race was considered as a risk factor for nonfunctional overreaching (NFO) or the overtraining syndrome (OTS). The results show that, after 3 months of supplementation, the testosterone/cortisol ratio changed in a statistically significant manner, thereby protecting the athletes from NFO and OTS. Antioxidant activity was also measured by quantifying the scavenging ability of the human serum on the synthetic free radical DPPH. After 3 months of fungal supplementation, the data demonstrate an increased scavenger

capacity of free radicals in the athletes' serum after the race, thereby protecting the athletes from oxidative stress [36]. It also helps to reduce the lactic acid accumulation in the muscles. The reduction of lactic acid is the reason of reduction in exhaustion and stress, and thus improves physical performance and increases the stamina. By using swimming test the similar results were found in a rat study [37, 38].

Now, researchers believe that *Cordyceps* is the best known multimedicine or complete energy package (dietary supplements) or booster for increasing physical stamina. Thus, consumption of *Cordyceps* by human led individual to great physical enhancement, extra endurance and the anti-fatigue ability [39-41].

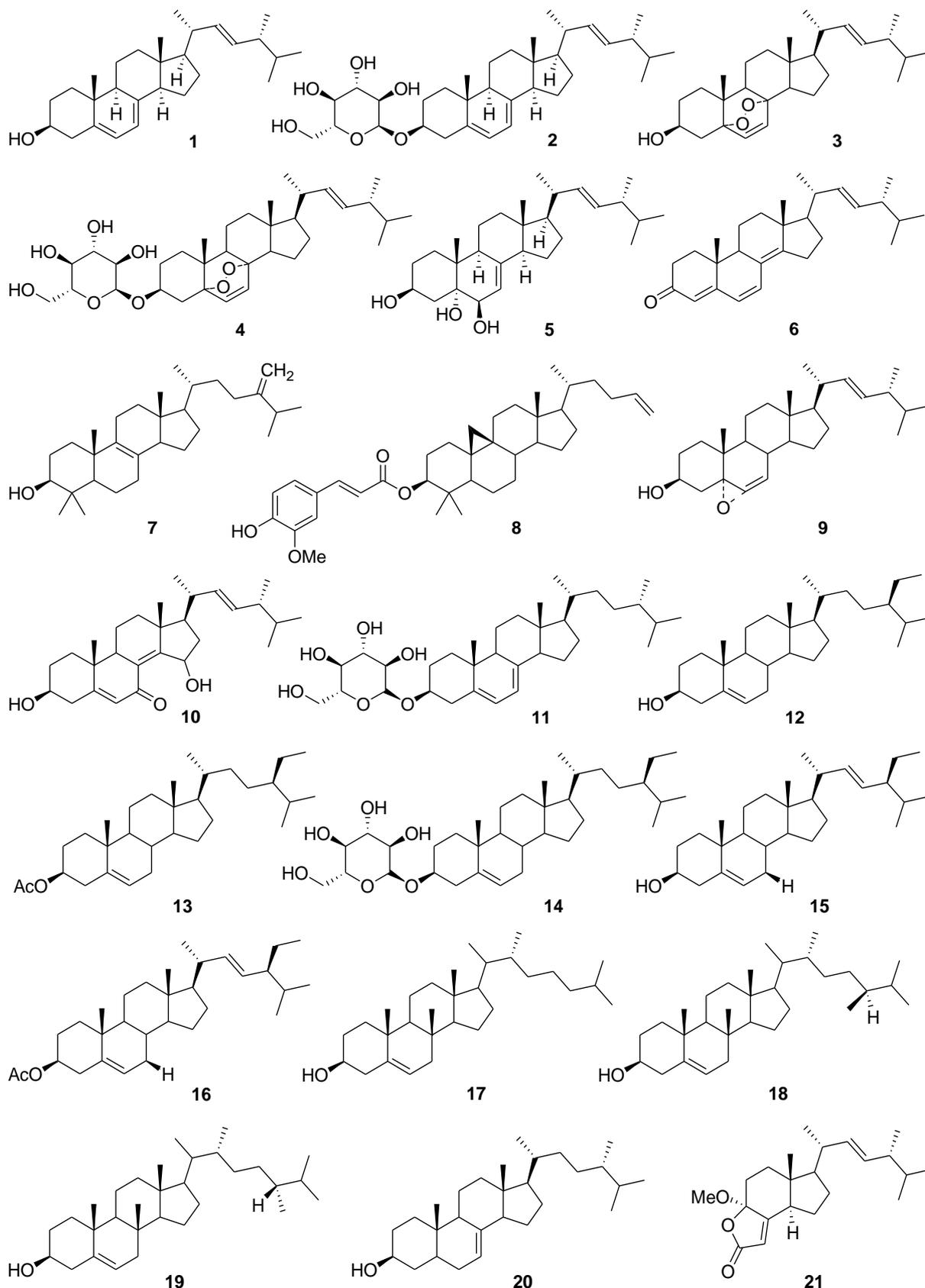
#### 4. *Cordyceps* medicinal importance and phytochemical constituents

*Cordyceps* has various biological effects on the human organ systems viz., on the, central nervous system (sedative, anticonvulsant and cooling effects), respiratory system (relaxant role in the bronchi, it increases adrenaline secretion from the adrenal glands and important role in tracheal contraction caused by histamine, antitussive, expectorant and anti-asthmatic action and prevents pulmonary emphysema), endocrine system (it can increase plasma corticosterone levels thus affects male hormone), nourishing the kidney, renal, hyposexuality and hyperlipidemia *etc.* [42]. It also has been used as an antitumor and haemostatic, mycolytic, antiasthmatic, and expectorant *etc.*, few pharmacophore such as cordycepin and polysaccharides are mostly detected as cytotoxic, antibiotic, antitumor, antioxidation and boosting the immune system *etc.* [43-48].

*Cordyceps* contains multicomponent biologically active pharmacophores such as sterols [39] fatty acids, inorganic metals [49], polysaccharides, phenols, almost all the essential amino acids, few aliphatic and aromatic ketones, aldehydes, and essential oil *etc.* Biologically active pharmacophores are discussed one by one as follows:

##### 4.1 Sterols

Sterols are one of the major constituent extracted from *Cordyceps*. The glycosylated form of ergosterol peroxide was found to be a greater inhibitor to the proliferation of K562, Jurkat, WM-1341, HL-60, and RPMI-8226 tumor cell lines [39, 43-48, 50-54]. Examples are, ergosterol (1), ergosteryl-3-*O*- $\beta$ -D-glucopyranoside (2), ergosterol peroxide (3), 5 $\alpha$ ,8 $\alpha$ -epidioxy-24(*R*)-methylcholesta-6,22-dien-3 $\beta$ -D-glucopyranoside (4), 5 $\alpha$ -ergosta-7,22-diene-3 $\beta$ ,5 $\beta$ ,6 $\beta$ -triol (cervisterol) (5), ergosta-4,6,8(14),22-tetraen-3-one (6, ergone), 4,4-dimethyl-5 $\alpha$ -ergosta-8,24(28)-dien-3 $\beta$ -ol (7), 3-*o*-ferulylcycloartenol (8), 5 $\alpha$ ,6 $\alpha$ -epoxy-24(*R*)-methylcholesta-7,22-dien-3 $\beta$ -ol (9), 3 $\beta$ ,15 $\beta$ -dihydroxy-(22*E*,24*R*)-ergosta-5,8(14),22-trien-7-one [H1-A] (10), 22, 23-dihydroergosteryl-3-*O*- $\beta$ -D-glucopyranoside (11),  $\beta$ -sitosterol (12),  $\beta$ -sitosterol-3-*O*-acetate (13), daucosterol (14), stigmaterol (15), stigmaterol 3-*O*-acetate (16), cholesterol (17), campesterol (18), dihydrobrassicasterol [D5-ergosterol] (19); fungisterol [D7-ergosterol] (20), and (17*R*)-17-methylcisterol (21).



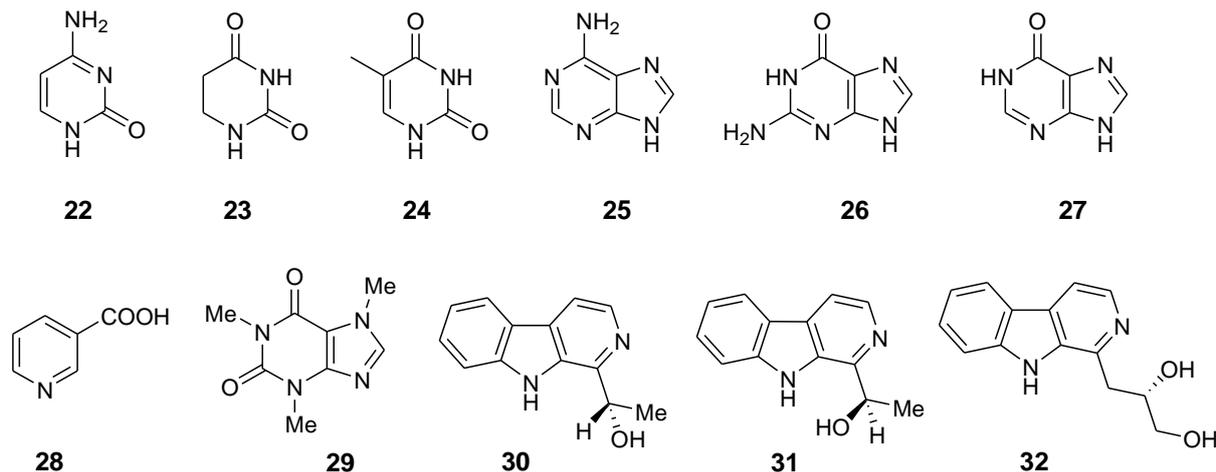
Ergosterol (1) and its derivatives have diverse medicinal value including cytotoxicity and antimicrobial activity [50, 52-54]. Ergosterol (1) is well known as diuretic bioactive compound with excellent efficacy [13]. Ergosterol derivative (2) have significant inhibition of superoxide anion generation and elastase release with  $IC_{50}$  values of  $5.42 \pm 0.50$  and  $5.62 \pm 0.37 \mu\text{M}$ , respectively [53] and ergosterol peroxide (4) act as a greater inhibitor to the proliferation of K562, Jurkat, WM-1341, HL-60 and RPMI-8226 tumor cell lines and could be a

potential anticancer property [43]. Sterol (5) improved kidney function in renal diseases, including IgA nephritis, autoimmune nephritis, and lupus nephritis by inhibiting IL-2 formation by monocyte and proliferation of mesangial cells and lymph node and also preventing and treating bronchial hyper responsiveness and acute asthma attack and improving pulmonary function. H1-A (10) can suppress the activated human mesangial cells HMC and alleviate IgAN (Berger's disease) with clinical and histological improvement [7].

#### 4.2 Nitrogenous compounds

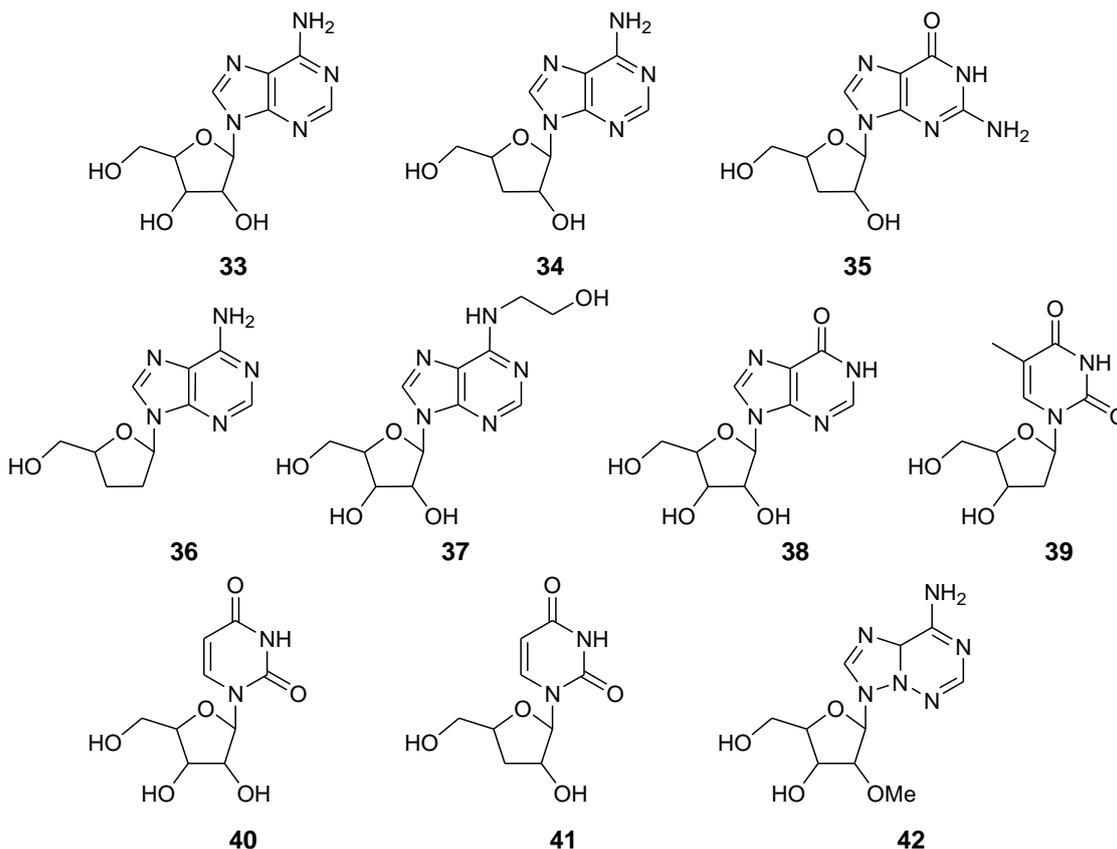
Another major constituent<sup>[55]</sup> extracted from *Cordyceps* are nitrogen containing compounds which includes nitrogenous bases, nucleosides and nucleosides etc. These are as follows:

**Nitrogenous base:** Cytosine (22), uracil (23), thymine (24), adenine (25), guanine (26), hypoxanthine (27), 2-nicotinic acid (28), caffeine (29), cordysin C (30), cordysin D (31), and cordysin E (32).



**Nucleosides**<sup>[55]</sup>: Adenosine (33), cordycepin (34), guanosine (35), dideoxyadenosine (36), N6-(2-hydroxyethyl) adenosine (37), inosine (38), thymidine (39), uridine (40), dideoxyuridine (41), and cordysin B (42). All nitrogenous bases and nucleosides can play a major role in the biological system. Adenosine (33) has anticonvulsant activity, inhibits cancer cell growth, anti-inflammatory and other effect<sup>[5, 9, 10, 16, 56-58, 60-62]</sup>. Cordycepin (34) has been well characterized<sup>[57, 58]</sup> and can have a role in DNA repair mechanism for antitumor response<sup>[31]</sup> and inhibit the phosphorylation of Akt and p38 in dose-dependent manners in LPS-activated macrophage. It also helps to decrease the expressions of

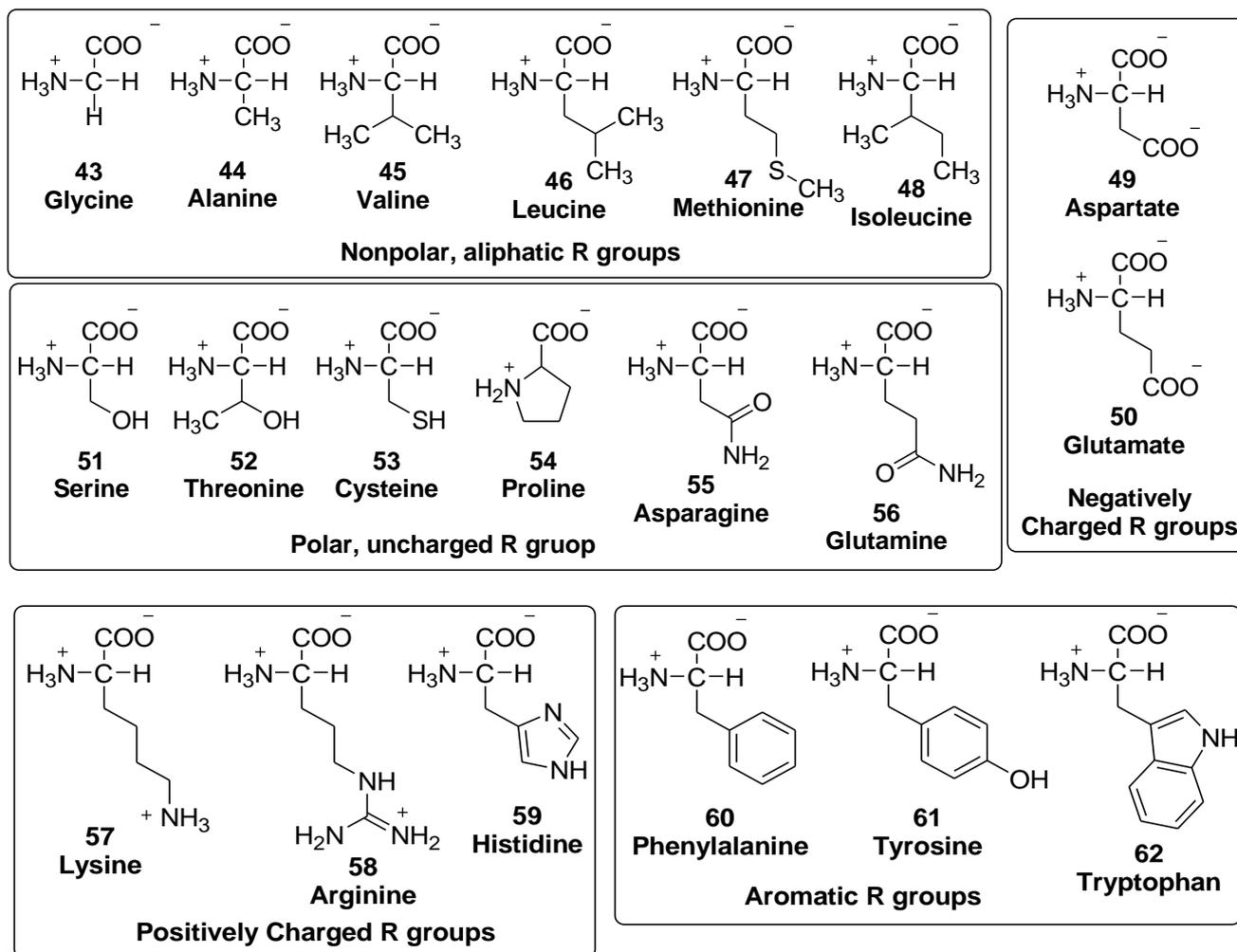
cyclooxygenase-2 (COX-2) and inducible nitric oxide synthase (iNOS) in RAW 264.7 cell and has good effect on diabetic osteopenia in diabetic rats<sup>[63]</sup>. The significant effect of Cordycepin (Cordymin) on diabetic osteopenia might be directly through weakening of ALP and TRAP activity and mediate through recovery of  $\beta$ -cells and lowering the concentration of serum glucose, which subsequently triggered a lower extent of oxidative stress in diabetic rats. Other uses of Cordycepin as an antitumor, antibacteria, antiviral, antinsecticidal, anti-inflammatory, analgesic effect, and can stimulate steroidogenesis and enhances immunity<sup>[64-67]</sup>.



### 4.3. Proteins and amino acids and polypeptides

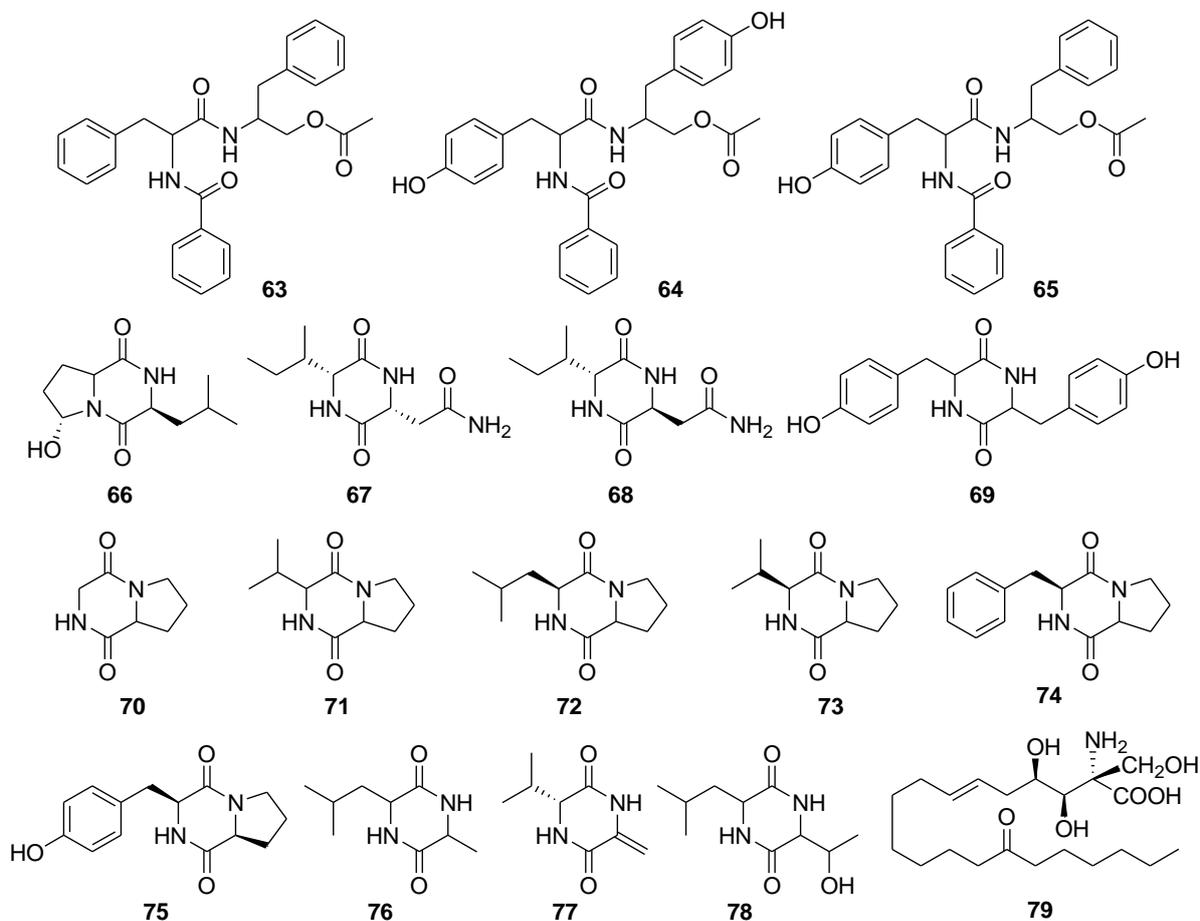
*Cordyceps* contains many amino acids (43-62) and polypeptides, which played an important role in clinical trials. *Cordyceps* contain crude protein which is made up of 18 amino acids such as aspartic acid, threonine, serine,

glutamate, proline, glycine, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine, cystine, cysteine and tryptophan and among these glutamate, arginine and aspartic acid have highest content.



**Peptides** [53, 58]: Aurantiamide acetate (63), cordyceamides A (64), cordyceamides B (65), cordysin A (66), cordycedipeptide A (3-acetamino-6-isobutyl-2,5-dioxopiperazine) (67), 3-isopropyl-6-isobutyl-2,5-dioxopiperazine (68), 3,6-di(4-hydroxy)benzyl-2,5-dioxopiperazine (69), cyclo-(Gly-Pro) (70), cyclo-(Val-Pro) (71), cyclo-(Leu-Pro) (72), cyclo-(L-Pro-L-Val) (73), cyclo-(L-Phe-L-Pro) (74), cyclo-(L-Pro-L-Tyr) (75), cyclo-(Ala-Leu) (76), cyclo-(Ala-Val) (77), cyclo-(Thr-Leu) (78), and myriocin (79). cordyceamides A (64) and B (65) as well as cordycedipeptide A (67) act as cytotoxic against L-929, A375 and Hela cell lines. Cordycedipeptide A (67) showed significant IC<sub>50</sub> value of 6.30 mg/mL (L-929), 9.16 mg/mL

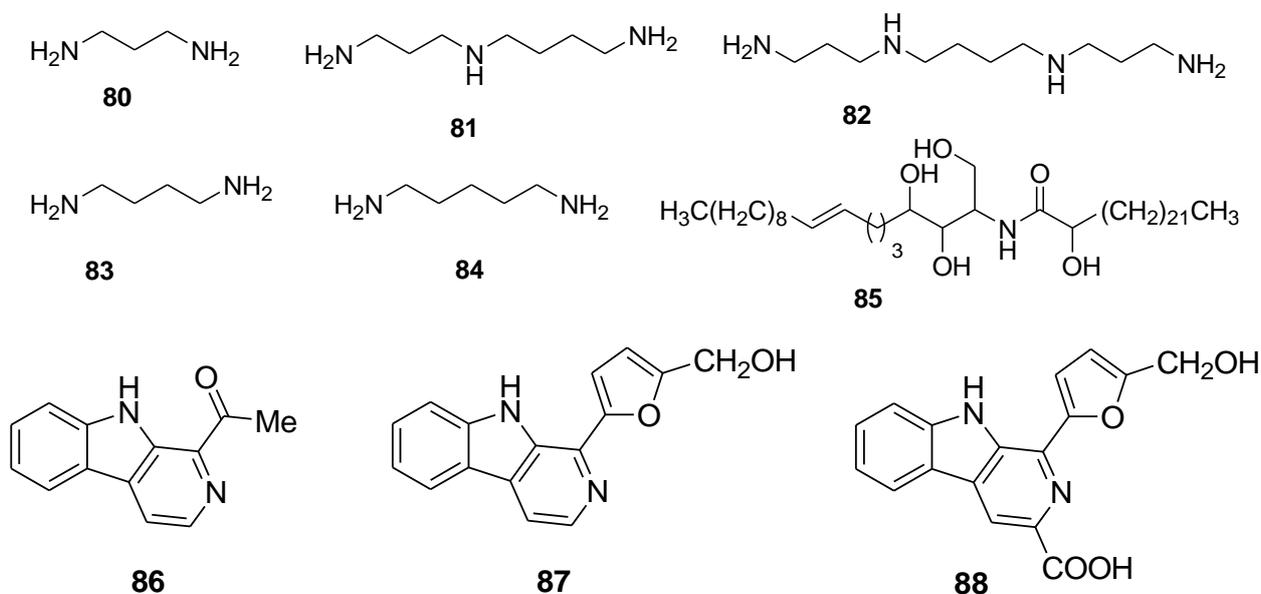
(A375). 64 showed better effect than 65 on L929 cell and A375 cell, but on Hela cell 65 showed better effect. Jia *et al.* [57] reported that Cordycedipeptide A (68) the cytotoxic activities of the constituent to L-929, A375, and Hela and its better effect on several tumor cell lines. Peptide 75 reported as good antifungal [68] as well as antimicrobial property [69]. Myriocin (79, antibiotic ISPI or thermozyiocidin) is a typical amino acid which is responsible for inhibit the upregulated expression of cyclin D1 induced by high concentrations of glucose, restoring the expression of cyclin D1 [70]. Some macromolecule polypeptides isolated from *C. sinensis* could be used for the treatment of hypertension.



They significantly reduce the mean arterial pressure of rats and induce a direct endothelium dependent vasorelaxant effect by stimulating the production of nitric oxide and endothelium-derived hyperpolarizing factor<sup>[71]</sup>.

**Amines and polyamines** <sup>[20, 53]</sup>: 1,3-Diamino propane (80),

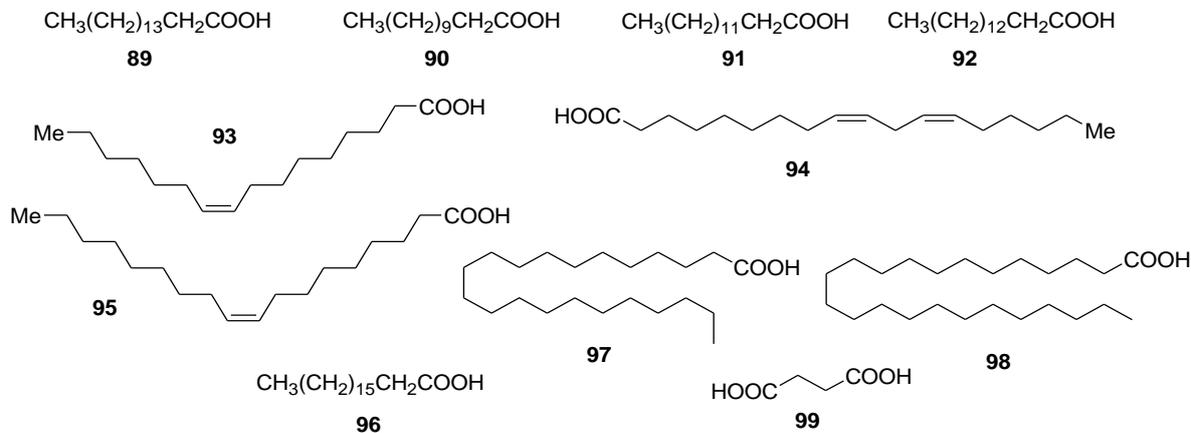
spermidine (81), spermine (82), putrescine (83), cadaverine (84), *N*-(2'-hydroxy-tetracosanoyl)-2-amino-1,3,4-trihydroxy-octadec-8*E*-ene(tetracosanamide) (85), 1-acetyl-a-carboline (86), perlolyrine (87), flazin (88) and including all nitrogenous compounds.



**4.4 Fatty acids and other organic acids**

Unsaturated fatty acids are the components <sup>[53, 72]</sup> which playing a major role in cells or in living host. These have a

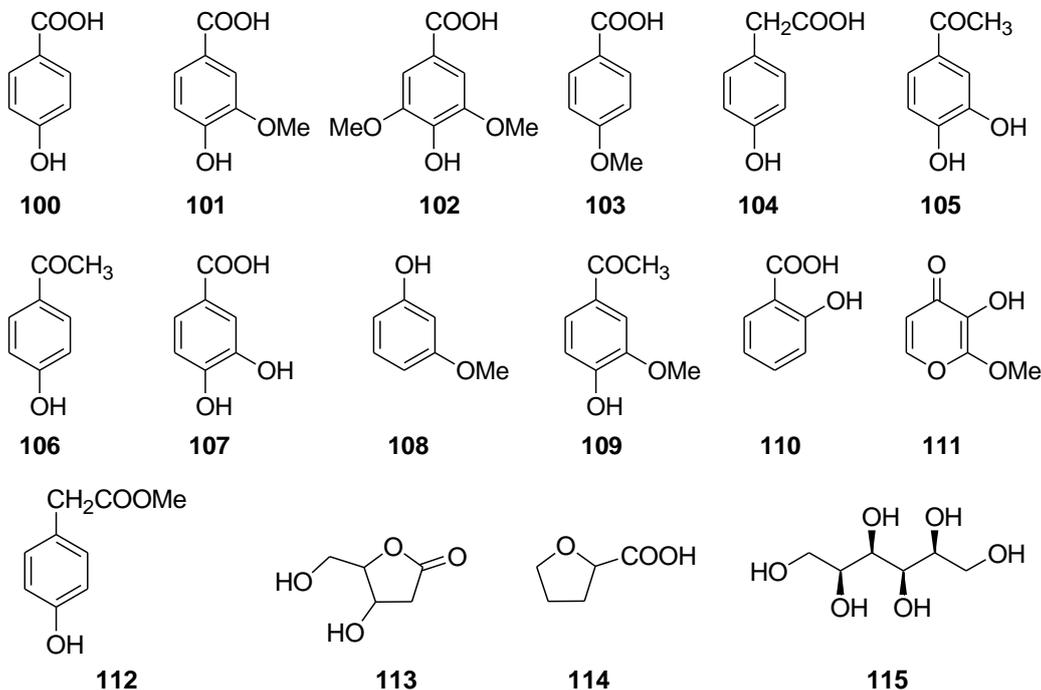
unique function of decreasing blood lipids and protecting against cardiovascular disease.



The content of unsaturated fatty acid is higher than that of saturated fatty acid in commercial preparations of *Cordyceps*. Examples are Palmitic acid (89), lauric acid (90), myristic acid (91), pentadecanoic acid (92), palmitoleic acid (93), linoleic acid (94), oleic acid (95), stearic acid (96), docosanoic acid (97, behenic acid), lignoceric acid (98, tetracosanoic acid), and succinic acid (99).

*p*-Hydroxybenzoic acid (100), vanillic acid (101), syringic acid (102), *p*-methoxybenzoic acid (103), *p*-hydroxyphenylacetic acid (104), 3,4-dihydroxyacetophenone (105), 4-hydroxyacetophenone (106), protocatechuic acid (107), 3, *p*-methoxyphenol (108), acetovanillone (109), salicylic acid (110), 3-hydroxy-2-methyl-4-pyrone (111), methyl *p*-hydroxyphenylacetate (112), 2-deoxy-D-ribose-1,4-lactone (113), and furancarboxylic acid (114).

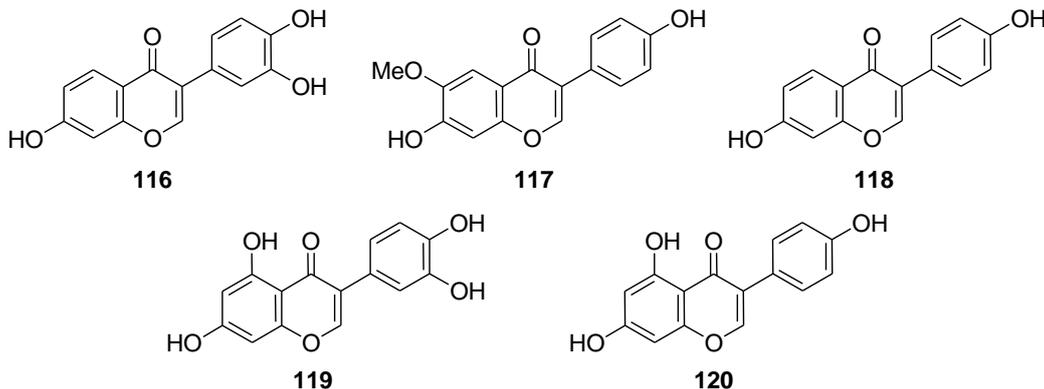
**4.5 Phenolics and acids** [53]



**4.6 Isoflavones** [53]

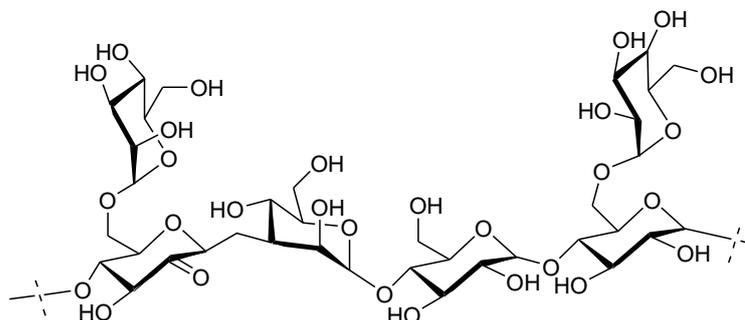
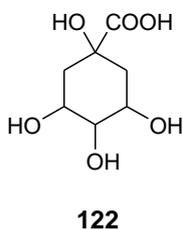
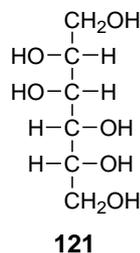
3,4,7-Trihydroxyisoflavone (116), glycitein (117), daidzein (118), orobol (119), and genistein (120). Compound 116

displayed significant scavenging of DPPH free radicals with IC<sub>50</sub> values of 31.97 μM.



#### 4.7 Sugar derivatives and polysaccharide <sup>[73-81]</sup>

Polysaccharides (PS) are the major bioactive constituents of *Cordyceps* which have proven anticancer and immunomodulation activities <sup>[83]</sup> and other notable health effects such as anti-oxidation etc. <sup>[76]</sup> Some glucose and polysaccharide derivatives were isolated from *Cordyceps* are D-mannitol (121), cordycepic acid (122), CS-F30 [Gal:Glc:Man = 62:28:10] (123), CS-F10 [Gal:Glc:Man =



**130**, Predicted structure of CPS-2 isolated from the fruiting bodies of cultured *C. sinensis*

In *Cordyceps*, polysaccharides are well explored as a medicinally important pharmacophore <sup>[80, 82]</sup>, such as D-Mannitol and Cordycepic acid. These polysaccharides are well explored as an effective in regulating blood sugar <sup>[73]</sup>, antimetastatic, immunomodulating, antitumor effects <sup>[43, 77]</sup>, antioxidants <sup>[45, 75]</sup>, hypoglycemic <sup>[73, 74]</sup>, antiinfluenza and hypo-cholesterolemic effects. Cordycepic acid is another very important medicinal components and used with variety of medicines <sup>[31, 81]</sup> and can be used in treating liver fibrosis diuretic, improving the plasma osmotic pressure, and anti-free radical <sup>[76]</sup>.

Polygucans having high molecular weight tends to have greater water solubility and have more effective as an anti-tumour <sup>[79]</sup>. The crude exopolysaccharide (EPS) isolated from the mycelia liquid culture medium by ethanol precipitation contained 65–70% sugar and about 25% protein, suggesting that the EPS was composed of polysaccharide–protein complexes and showed moderate antioxidant activities with a Trolox equivalent antioxidant capacity of 35–40  $\mu\text{mol}$  Trolox/g and a ferric reducing ability of plasma of 50–52  $\mu\text{mol}$  Fe(II)/g. It also exhibited moderate radical scavenging and ferric reducing activities <sup>[84-90]</sup>. Shao, *et al.* first time reported that polysaccharide (glucose: mannose: galactose, 1:0.6:0.75) from *Cordyceps* can protects against the free radical-induced neuronal cell toxicity <sup>[72]</sup>. An acid polysaccharide (APS, 122) was isolated from cultivated *C. sinensis* mycelia contains mannose, glucose, and galactose in an approximate ratio of 1: 2: 1 <sup>[21]</sup>. APS possesses protective effects in PC1<sub>2</sub> cells against H<sub>2</sub>O<sub>2</sub>-induced injury <sup>[72]</sup>. Polysaccharide CS-F30 (123) increased the activities of hepatic glucokinase, hexokinase and glucose-6-phosphate dehydrogenase and decreased glycogen content in the liver <sup>[85]</sup> and CS-F10 (124) significantly increased the activity of hepatic glucokinase in streptozotocin (STZ)-induced diabetic mice leading to reduced hepatic glucose output <sup>[75]</sup>. CSP-1 (128) had strong antioxidant activities, which can be used to

reduce the blood glucose level <sup>[6]</sup> and treat renal failure. CSP-1 (128) showed hypoglycemic properties which increased circulating insulin level in diabetic animals, due to stimulate pancreatic release of insulin and/or reduce insulin metabolism <sup>[6]</sup>. A water-soluble polysaccharide named CPS-1 (129) had been isolated from *C. sinensis* mycelium having composition of glucose, mannose, and galactose in approximate ratio of 2.8: 2.9: 1 and can be used as scavenge hydroxyl radicals and reduce power- and Fe<sup>2+</sup> chelating. CPS-2 (130) contains mannose, glucose, and galactose in the approximate ratio of 4: 11: 1 <sup>[89]</sup>. Wang *et al.* found that 130 could reduce PDGF-BB-induced cell proliferation through the PDGF/ERK and TGF $\beta$ 1/Smad pathways <sup>[90]</sup> and fibrinolytic activity <sup>[88]</sup>. Cheung *et al.* reported that Cordysinocan (131) contains glucose, mannose and galactose in a ration approximate of 2.4: 2: 1 and used to induced the cell proliferation and the secretion of interleukin-2, interleukin-6 and interleukin-8 in cultured T-lymphocytes and triggering the immune responses <sup>[84]</sup>. The heteropolysaccharide PSA (132) composed of D-glucose, D-galactose, and D-mannose in approximate ration of 2: 1: 1 possess strong inhibitory activity against cholesterol esterase and may be a potential agent to control hypercholesterolemia <sup>[87]</sup>.

#### 4.8 Inorganic Metals ion and elements <sup>[49, 91]</sup>

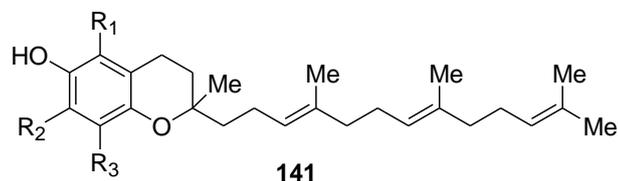
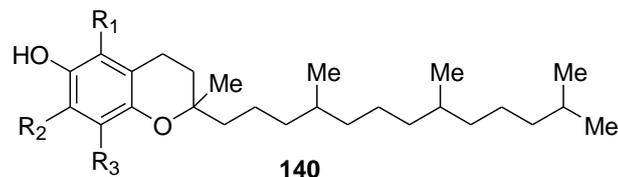
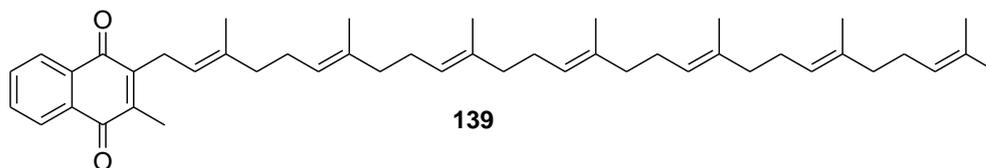
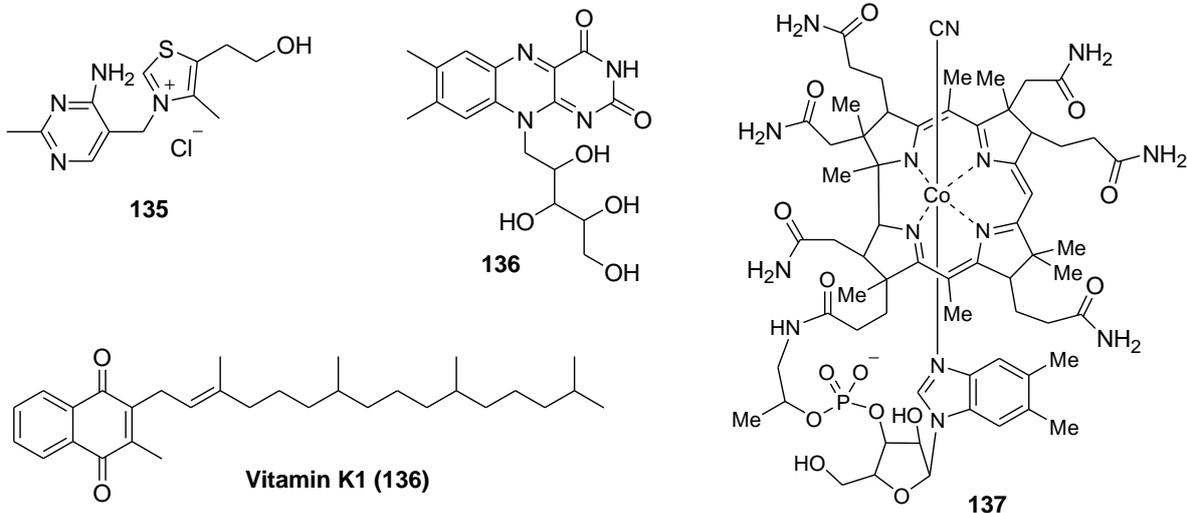
Alkali Metals: K<sup>+</sup>, Na<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, and Al<sup>3+</sup>.

Metals: Fe<sup>2+</sup>, Cu<sup>2+/+</sup>, Mn<sup>2+</sup>, Zn<sup>2+</sup>, Ni<sup>2+</sup>, Sr<sup>2+</sup>, Ti<sup>3+</sup>, Cr<sup>2+</sup>, and V<sup>3+</sup>.

Non Metal: P<sup>3+/5+</sup>, Se<sup>2+</sup>, Si<sup>4+</sup>, and Ga<sup>3+</sup>.

#### 4.9 Vitamins <sup>[49, 91]</sup>

Vitamin B1 (thiamine hydrochloride, 135), vitamin B2 (riboflavin, 136), vitamin B12 (137), vitamin E (tocopherols (140), tocotrienols (141)), vitamin K1 (phylloquinone, 138), and vitamin K2 (Group of menaquinone, 139).



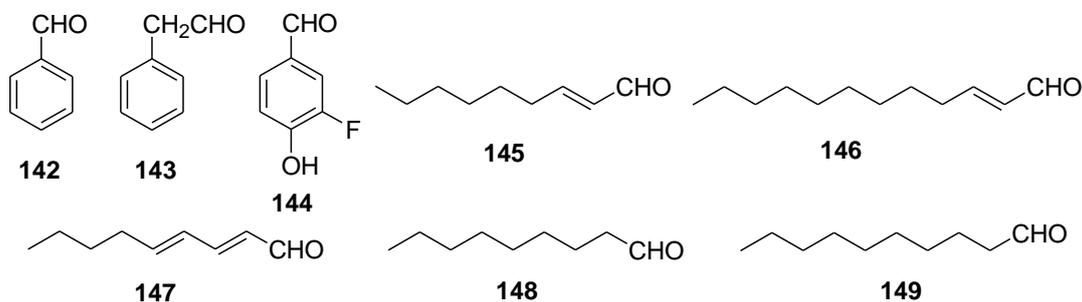
**Forms of Vitamin E**

- $\alpha$  if,  $R_1 = R_2 = R_3 = \text{CH}_3$
- $\beta$  if,  $R_1 = R_3 = \text{CH}_3, R_2 = \text{H}$
- $\gamma$  if,  $R_1 = \text{H}, R_2 = R_3 = \text{CH}_3$
- $\delta$  if,  $R_1 = R_2 = \text{H}, R_3 = \text{CH}_3$

**4.10 Volatile compounds** [49, 91]

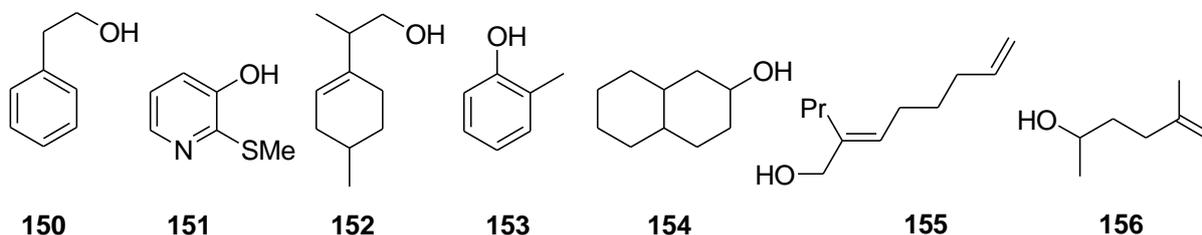
*Aldehydes:* Benzaldehyde (142), benzeneacetaldehyde (143), 4-fluoro-3-hydroxy-benzaldehyde (144), (*E*)-2-nonenal (145),

(*E*)-2-dodecenal (146), (*E,E*)-2,4-nonadienal (147), nonanal (148), and decanal (149).

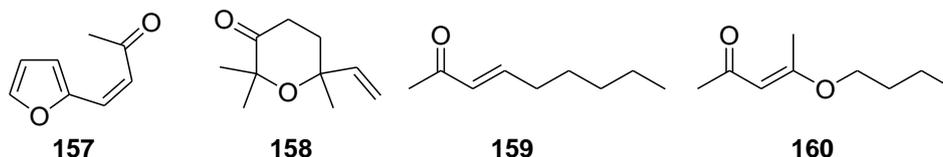


*Alcohols and phenols:* Phenylethyl alcohol (150), 2-(methylthio)-3-pyridinol (151), *p*-menth-4(*E*)-en-9-ol (152), 2-methyl-phenol (153), decahydro-2-naphthalenol (154), 2-

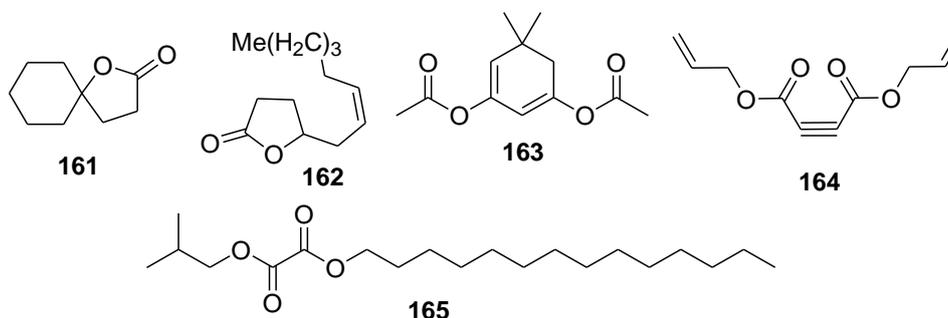
butyl-2,7-octadien-1-ol (155), and 5-methyl-5-hexen-2-ol (156).



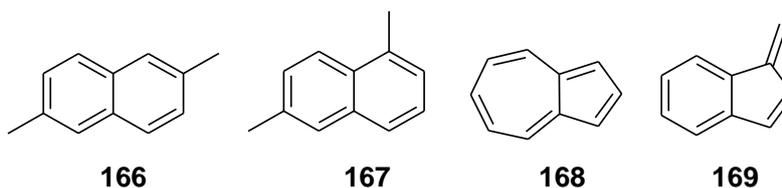
**Ketones:** 4-(2-Furanyl)-3-buten-2-one (157), 6-Ethenyldihydro-2,2, 6-trimethyl-2H-pyran-3(4H)-one (158), *trans*-3-Nonen-2-one (159), and 4-Butoxy-3-penten-2-one (160).



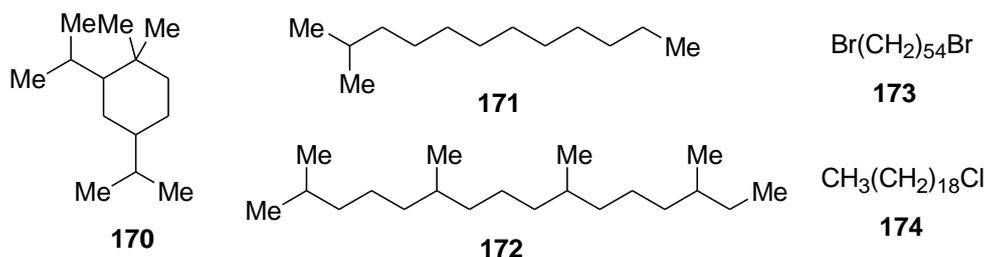
**Esters:** 1-Oxaspiro (4, 5)decan-2-one (161), (Z)-Dihydro-5-(2-octenyl)-2(3H)-furanone (162), 1,3-Cyclohexadiene-1,3-diol, 5,5-dimethyl-diacetate (163), 2-Butynedioic acid, di-2-propenyl ester (164), and Oxalic acid, isobutyl tetradecyl ester (165).



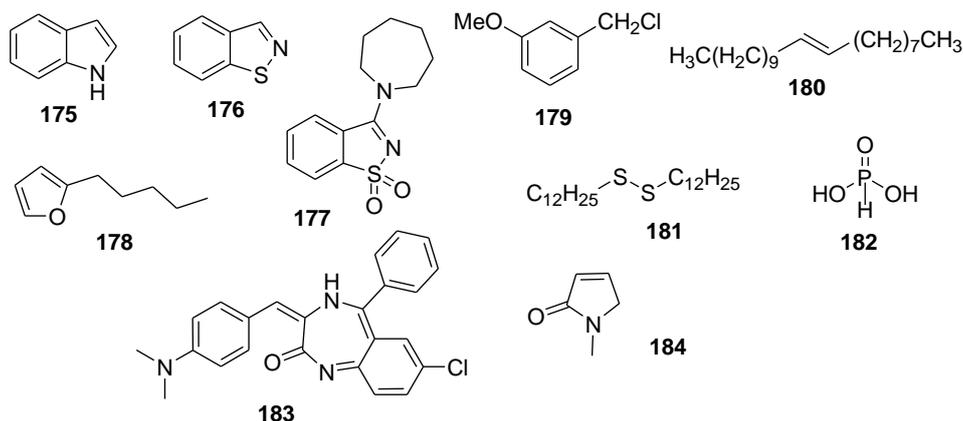
**Aromatics:** 2,6-Dimethylnaphthalene (166), 1,6-dimethyl-naphthalene (167), azulene (168), and 1-methylene-1H-indene (169).



**Alkanes:** 2, 4-Diisopropyl-1,1-dimethyl-cyclohexane (170), 2-methyl-dodecane (171), 2,6,10,14-tetramethyl-hexadecane (172), 1,54-dibromo-tetrapentacontane (173), and 1-chloro-nonadecane (174).

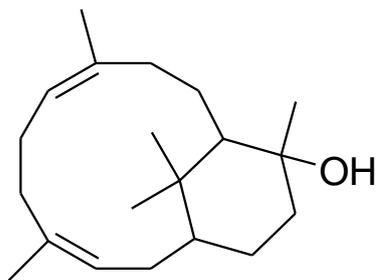


**Others:** Indole (175), 1,2-benzisothiazole (176), 1,2-benzisothiazole, 3-(hexahydro-1H-azepin-1-yl)-1,1-dioxide (177), 2-pentyl-furan (178), 1-(chloromethyl)-3-methoxy-benzene (179), (E)-9-eicosene (180), ditert-dodecyl disulfide (181), phosphonic acid (182), 7-chloro-2,3-dihydro-3-(4-*N,N*-dimethylaminobenzylidene)-5-phenyl-1H-1,4-benzodiazepin-2-one (183), and 1,5-dihydro-1-methyl-2H-pyrrol-2-one (184).



#### 4.11 Essential oils

A number of essential oils has been identified using gas chromatography (GC–MS). Verticilol (**185**) has been found in *C. sinensis* which indicates anti-tussive and expectorant effects of *C. sinensis* [92, 93].



**185**

#### 5. Conclusion

Yarsagumba is one of the world rarest fungal species known as “summer plant and winter insect” so called the mysterious “half-caterpillar-half-mushroom”. This fungus specially used for food verbiage in China and south Asian countries, since ancient time and used as various medicinal purposes. Recent studies says that, Yarsagumba is a complete package or dietary supplements for sportsperson which results in increase body energy, stamina, endurance, strength, and caring body diseases. This is because the availability of variety of biologically active pharmacophores present in Yarsagumba. Thus, in this text we tried to summarize, the benefits of Yarsagumba specially for sportsperson due to biologically active pharmacophores present in Yarsagumba which are actually responsible for better efficacy of the body.

#### 6. Acknowledgement

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#### 7. Conflicts of Interest

The authors have no conflicts of interest to declare.

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