Review

Authentication and quality control of *Cordyceps sinensis*, a traditional Chinese medicine known as winter-worm summer-grass

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SUMMARY

*Cordyceps*, one of the most valued traditional Chinese medicines, consists of the dried fungus *Cordyceps sinensis* growing on the larva of caterpillar. It is also known as “winter-worm and summer-grass” because of its appearance during different seasons. The parasitic complex of the fungus and the caterpillar is found in soil of a prairie at an elevation of 3,500 to 5,000 meters in northwestern part of China. According to Chinese medicinal theory, *Cordyceps* is used to replenish the kidney and soothe the lung, and indeed many clinical applications have been reported. The natural *Cordyceps* is rare and expensive on the local market, and therefore, several mycelial strains have been isolated from natural *Cordyceps* and manufactured in large quantities by fermentation technology, and they are commonly sold as health food products in Orient. The adulterants of *Cordyceps* are commonly found on the market, and therefore the authentication of these products has to be defined. Having the urgent need from current market, different chemical markers such as nucleoside, ergosterol, mannitol and polysaccharide are being used for quality control of *Cordyceps*. Unfortunately, these markers are far from optimization, and therefore extensive works are needed to define the pharmacological efficiency of these markers.

Key words: *Cordyceps*; Quality control; Chemical marker

INTRODUCTION

*Cordyceps sinensis* is the complex of fungus *Cordyceps sinensis* (Berk.) Sacc. (Clavicipitaceae) growing on the larva of *Haplinus armeniacus* Oberthür (caterpillar) that lives few inches underground. It is also commonly known as *Cordyceps*, or “Dong Chong Xia Cao” (winter-worm and summer-grass) in Chinese, because of its appearance during different seasons. *Cordyceps* has been used in China for medication over few hundred years. *Cordyceps* is first recorded in “Ben Cao Cong Xin” by Wu Yiluo in 1757 AD. Later on it was revealed that the original description of *Cordyceps* should be in “Ben Cao Bei Yao” by Wang Ang in 1694 AD, which wrote: “*Cordyceps* is sweet in taste and neutral in nature, and replenishing the kidney and soothing the lung, arresting bleeding, resolving phlegm, and killing the cough”.

*Cordyceps* was known to Europe in 17th century. In 1723 AD, *Cordyceps* was brought from China to France as Materia Medica, and which was presented at the Conference of Paris Science Academic Institute.
Then, *Cordyceps* was considered as a precious medical material and recorded at the memo of the Conference in 1727 AD. Hundred years later, Italian scholar Saccardo in 1878 AD named *Cordyceps* derived from China officially as *C. sinensis*; this nomenclature was adopted until today. Functionally, *Cordyceps* is well known to ensure the normal functioning of various parts of the body, to strengthen the immune system and to promote overall vitality and longevity (Zhu et al., 1998a, b). Today, *Cordyceps* is commonly used in many hospitals in China and as a household remedy. However, more than hundred different types of *Cordyceps* or its substitutes have been found worldwide today. Thus, the authentication of *Cordyceps* is a serious problem on the market. Here, we discuss the chemical composition of natural and cultured *Cordyceps* and their problems in authentication and quality control.

**Natural and cultured Cordyceps**

*Cordyceps* composes of fungus fruiting body and larva of the host, and its distribution is closely related to distribution of the host. At present, possible hosts of *C. sinensis* have been identified (Li and Tsim, 2004). Many *Cordyceps*-related species could be found, which are based on different fungus growing on different insect hosts; however, most of them are not considered as *Cordyceps* for clinical usage, except *C. sinensis* that is listed officially in Chinese Pharmacopoeia (Zeng, 2005). China is the major producer of *Cordyceps*. In China, the parasitic complex is found in soil of a prairie at an elevation of 3,500 to 5,000 meters, mainly in the provinces of Qinghai, Tibet, Sichuan, Yunnan and Gansu (Fig. 1A).

Formation of *Cordyceps* can be divided into 3 stages (Fig. 1B): infection, parasitism (development of fungus before the insect death) and saprophyte (growth of fungus after the insect death). After the infection, *Cordyceps* fungus makes use of the bowels of the host as nutrient and starts to grow. The mycelia creep over the insect body while the host is still alive. Subsequently, the color of the host surface (shell) will fade in few days from dark brown-yellow turn into light yellow, and then the entire body is covered by gray mycelia. After the host has died, the coarsely mycelia will form a hard

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Fig. 1. (A) A map shows the distribution of *Cordyceps* in China. (B) Host (*H. armatorianus*) can be invaded at the state of larva by *C. sinensis*. After the infection, *Cordyceps* fungus makes use of the bowels of the host as nutrient and starts to grow. After the host has died, the coarsely mycelia will form a hard tissue. If the condition is suitable, the mycelia in the host will grow out through the oral cavity, and form the fruiting body; therefore, this is the formation of *Cordyceps*. (C) Freshly collected *Cordyceps* is shown. Arrowhead in (left panel) indicates a living *Cordyceps* before the collection.

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tissue. If the condition is suitable, the mycelia within the host will grow out through the oral cavity, and form the fruiting body; therefore, this is the formation of Cordyceps. The host loses its biological and chemical characteristic, and eventually occurred by C. sinensis mycelia. The collected Cordyceps have to be dried before they are sold on the market (Fig. 1C).

The growth of C. sinensis has a very restricted habitat, and the yield is decreasing every year. In 2001, a total of few thousands kg of Cordyceps were collected in China; this represents a decrease of over 70% as compared to 1978. Because of the environmental concerns, the Ordinance of Resources Protection on Wild Herbal Medicine was issued in 1987 by the Chinese Government, and therefore the collection of Cordyceps is being restricted. The price of Cordyceps is US$ 5,000 per kg in 2005, about 100 folds higher than that in 1980's.

Scientists in Orient have extensively developed substitutes by using mycelial fermentation that is deriving from natural Cordyceps. Up to date, more than 9 genera including 31 species have been isolated from natural C. sinensis. Mycelia, or fruiting bodies, of 16 species have been produced in large quantities by culture. More than 20 fermented products are commonly sold as health food products in China, and the annual production value is more than US$ 100 million.

Among all the fermented Cordyceps, CS-4 is the most common one and claimed to be isolated from C. sinensis; CS-4 is known to be Paecilomyces hepialid. Fermentation methodology, chemical composition, therapeutic function, basic biology and toxicity of CS-4 have been investigated extensively. JinShuiBao capsule, the commercial product that derived from CS-4, has been sold and used in clinics throughout China. This product generates over several million US dollars of sales per year. Besides CS-4, several mycelial strains have been isolated from natural Cordyceps, and some of them are manufactured in large scale by fermentation (Yin and Tang, 1995). For instance, Symmenatum sinensis, Cephalosporium sinensis, Gliocladium roseum, and Mortierella hepiali are the nonssexual phase strains of Cordyceps; their commercial names in China are known as BaiJing, NingXinBao, XinCanBao and ZhiJing, respectively. In addition, Paecilomyces sinensis, Scytalidium hepiali, Tolypocladium sinensis, Hirsutella sinensis, Chrysosporium sinensis and others have also been isolated from natural Cordyceps and manufactured in large quantities by fermentation (Wang et al., 1993b; Zhu et al., 1998a, b). In addition, Cordyceps militaris is often used as a substitute of C. sinensis (Wang, 1995) in health food market of Orient, which is also known as Cordyceps from the north (Bei Chong Cao). Thus, the cultivated products of Cordyceps as health food products are very popular, but confusing, in Asia, and their marketable values are extremely high. However, the genuineness of these products is still doubtful, and on the other hand the adulterants of Cordyceps are commonly found on the market.

**Chemical and biological properties of Cordyceps**

The chemical composition of C. sinensis was first described in 1947 by Tang (Wang, 1995). In average, natural Cordyceps contains 25% protein, 8.4% fat, 18.5% fiber, 29% carbohydrate and 4.1% ash. In 1957, cordycepic acid, which was subsequently identified as D-mannitol, was isolated from C. sinensis, and which therefore has been used as a quality control marker of Cordyceps for a number of years (Wang and Pang, 1995; Yue et al., 1995). In 1964, 3'-deoxyadenosine, namely cordycepin, was isolated from C. militaris (Wang, 1995), a related species of C. sinensis commonly used as a substitute of Cordyceps; however, the existence of cordycepin in C. sinensis is controversial. Up to date, cordycepin has never been identified from C. sinensis. At present, C. sinensis is known to contain steroids, nucleosides, carbohydrates and amino acids. Subsequently, uracil, adenine, adenosine, trehalose, mannitol, ergosterol and stearic acid were identified from C. sinensis (Yu et al., 1981) (Fig. 2). A very common question is being asked for
many years regarding the values of Cordyceps. Is the worm or the fungus more important? In order to answer this question, the biological activity and chemical composition of the fruiting body and the worm were investigated (Li et al., 2002). The water extracts of the individual parts were analyzed by capillary electrophoresis, and the content of nucleosides was determined. The fruiting body and the worm showed a close resemblance in their nucleoside peaks and overall profiles, while the dry naïve worm with no Cordyceps mycelia showed a very distinct chemical profile (Fig. 3). In addition, similar amounts of polysaccharides were found in fruiting body and worm. Biologically, the anti-oxidating activity of Cordyceps, from either the fruiting body or worm, was determined; the water extracts of fruiting body and worm showed similar IC50 values in their inhibition of free radical formation (Li et al., 2002). On the other hand, the naïve worm did not show any anti-oxidating
activity at the range of mg/ml. These results suggest that the function of the worm in Cordyceps is to provide a growth medium for the fruiting body, and eventually, the worm is totally invaded by C. sinensis mycelia.

In Chinese medicinal theory, Cordyceps processes both “Yin-nourishing” and “Yang-invigorating” activities (Siu et al., 2004). Indeed, numerous reports have shown the pharmacological properties of either natural or cultured Cordyceps (reviews in Zhu et al., 1998a, b; Li and Tsim, 2004). Different therapeutic purposes of Cordyceps were reported to stimulate immune response; inhibit cancer growth; protect kidney and liver; stimulate cardiovascular circulation; lower blood glucose; and against free-radical formation. Although several functions of Cordyceps have been described, the comparison among different types, both natural and cultured, of Cordyceps in a defined biological activity has not been described. Several years ago, our laboratory had compared different types of Cordyceps by their anti-oxidating activities. The anti-oxidating activity of Cordyceps was compared by using different methods including the inhibition on xanthine oxidase, the induction of hemolysis in erythrocytes and the prevention of lipid peroxidation in liver (Li et al., 2001a). Water extract from natural or cultured Cordyceps significantly scavenged the formation of free radical. In the same study, the anti-oxidating activities of different cultured or natural products of Cordyceps were compared (Table 1). The natural Cordyceps from Tibet showed the strongest scavenging activity of free radical with an IC_{50} of 0.08 mg/ml, while Cordyceps from Yunnan had an IC_{50} of 0.24 mg/ml; the difference was ~3 folds between the two sources of Cordyceps. Similar difference could also be observed in cultured Cordyceps that was fermented from various producers. In contrast, different sources of Cordyceps, either natural or cultured Cordyceps, showed a close inhibition on the free radical-induced hemolysis of erythrocytes: their IC_{50} varied from 1.5 to 2.0 mg/ml. Furthermore, the anti-oxidating activity of Cordyceps could be enriched by ~15 folds in polysaccharide-enriched fraction after ion exchange column. By using the partial purified polysaccharide in the anti-oxidation assays, the increment of inhibition activity was ~25 folds in xanthine oxidase assay, ~11 folds in hemolysis assay and ~32 folds in lipid peroxidation assay. The result indicated that polysaccharide could be one of the active constituents in Cordyceps of having anti-oxidating activity (Li et al., 2001a).
Table 1. The inhibition of peroxide anion formation, hemolysis and lipid peroxidation by water extracts from different types of natural and cultured Cordyceps

<table>
<thead>
<tr>
<th>Sample</th>
<th>peroxide anion formation</th>
<th>hemolysis</th>
<th>lipid peroxidation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Cordyceps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qinghai</td>
<td>0.20^4</td>
<td>0.20</td>
<td>0.66</td>
</tr>
<tr>
<td>Xizang</td>
<td>0.08</td>
<td>0.23</td>
<td>0.52</td>
</tr>
<tr>
<td>Sichuan</td>
<td>0.08</td>
<td>0.17</td>
<td>0.39</td>
</tr>
<tr>
<td>Yunnan</td>
<td>0.24</td>
<td>0.30</td>
<td>0.71</td>
</tr>
<tr>
<td>Cultured Cordyceps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jiangxi</td>
<td>0.09</td>
<td>0.15</td>
<td>0.53</td>
</tr>
<tr>
<td>Huadong</td>
<td>0.21</td>
<td>0.18</td>
<td>0.68</td>
</tr>
<tr>
<td>Wanfong</td>
<td>0.34</td>
<td>0.18</td>
<td>0.57</td>
</tr>
<tr>
<td>Hebei</td>
<td>0.91</td>
<td>0.19</td>
<td>0.63</td>
</tr>
</tbody>
</table>

^a,b,c The IC50 in the inhibition and refer to reference (Li et al., 2001a). ^d The mean values of five determinations are presented. The SEM is less than 5% of the mean, which is not shown for clarity.

Quality control of Cordyceps

Natural Cordyceps are mainly found in the provinces of Qinghai, Tibet, Sichuan, Yunnan and Gansu of China; however, Qinghai and Tibet are believed to produce the best quality of Cordyceps, and their prices are much higher than those from other areas. In addition, different types of cultured Cordyceps are being sold on the current markets, and their prices are markedly lower than that of the natural one. According to the sources of Cordyceps, the market price of Cordyceps varies greatly, and unfortunately an absolute chemical marker for better quality or even the markers for authenticity of Cordyceps is missing. At present, the quality of these products is an emerging question concerned by the consumers. Under many circumstances, adenosine has been used as a marker for quality control of natural Cordyceps and cultured Cordyceps mycelia (Zheng, 2005). While, mannotol is used as a marker for quality control of Cordyceps mycelia because of its certain pharmacological activity (Chen et al., 1992; Wang and Pang, 1995). But all of these chemical markers are far from perfect.

Adenosine is not a good marker for Cordyceps

Nucleoside is believed to be the active component in Cordyceps. Indeed, Cordyceps contains a high concentration of adenosine, guanosine and uridine (Li et al., 2001b; c; Gong et al., 2004). Among these nucleosides, adenosine is considered to play a key role in many pharmacological effects of Cordyceps, which include the widespread effects on coronary and cerebral circulation, the prevention of cardiac arrhythmias and the functions in nervous system e.g. the inhibition of neurotransmitter release and the modulation of adenylate cyclase activity. The amount of nucleoside within Cordyceps changes according to different environmental conditions. Fresh natural Cordyceps contains very little amount of nucleoside, as compared to dry and processed Cordyceps (Li et al., 2001b), and more interestingly cultured Cordyceps mycelium contains high level of nucleosides (Table 2). Furthermore, humidity and heat significantly increased the amount of nucleoside in natural Cordyceps. Storage of Cordyceps at 75% relative humidity and 40°C for 10 days, the nucleoside content in natural Cordyceps markedly increased to about 4 folds. However, the effect of humidity and heat in altering the content of nucleotide could not be revealed in cultured Cordyceps mycelia (Li et al., 2001c). Therefore, it is believed that nucleosides in natural Cordyceps may be derived from the degradation of nucleic acids. In addition, recent studies from our laboratory indicated that the content of adenosine in Cordyceps has no obvious relationship with its anti-oxidating activity (Li et al., 2002). In addition,
Table 2. The contents of ergosterol, nucleosides and their bases in *Cordyceps*

<table>
<thead>
<tr>
<th>Marker</th>
<th>Natural <em>C. sinensis</em></th>
<th>Cultured <em>C. sinensis</em></th>
<th>Cultured <em>C. militaris</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Qinghai</td>
<td>Tibet 1</td>
<td>Tibet 2</td>
</tr>
<tr>
<td>Ergosterol</td>
<td>1.43&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td>Adenosine (+Adenine)</td>
<td>0.45</td>
<td>0.42</td>
<td>0.36</td>
</tr>
<tr>
<td>Cytosine</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Cytidine</td>
<td>0.29</td>
<td>0.19</td>
<td>0.32</td>
</tr>
<tr>
<td>Cordycepin</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Guanosine</td>
<td>0.20</td>
<td>0.18</td>
<td>0.32</td>
</tr>
<tr>
<td>Thymine</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Thymidin</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Uracil</td>
<td>+</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Uridine</td>
<td>0.66</td>
<td>0.83</td>
<td>0.83</td>
</tr>
<tr>
<td>2'-deoxyuridine</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Hypoxanthine</td>
<td>0.03</td>
<td>0.06</td>
<td>0.13</td>
</tr>
</tbody>
</table>

<sup>a</sup> The amount of marker is in mg/g of dry weight (Li et al., 2004a). The mean values of five determinations are presented. The SEM is less than 5% of the mean, which is not shown for clarity. <sup>b</sup>Undetectable. <sup>c</sup>Beyond lower limit of linear range of detection.

the hypolipidemic activity of adenosine has never been reported. Therefore, having adenosine as a marker for good quality of *Cordyceps* may not be indicative.

The level of ergosterol shows the characteristic of *Cordyceps*

Ergosterol is an unique component in fungi, and it is required for vitamin D<sub>3</sub> synthesis. Thus, ergosterol could be another choice of chemical marker for quality control of *Cordyceps*. Sterols and their derivatives have been isolated from natural and cultured *Cordyceps*; they are ergosterol, Δ<sub>7</sub> ergosterol, ergosterol peroxide, ergosteryl-3-O-β-D-glucopyranoside, 22,23-dihydroergosteryl-3-O-β-D-glucopyranoside, β-sitosterol, daucosterol, cholesterol, cholesteryl palmitate, campesterol and dihydrobrassicasterol. Ergosterol exists as free and combined forms in *Cordyceps*. Li et al. (1991) determined the amount of total (free and combined forms) ergosterol in *Cordyceps* by using HPLC, where the pre-treatment of sample was performed. However, the requirement for pre-treatment is time consuming and with poor reproducibility. The determination of free ergosterol in *Cordyceps* by using HPLC is easier to perform. The content of ergosterol is higher in cultured *Cordyceps* mycelia than that in natural *Cordyceps* (Table 2), and the level of ergosterol could reflect the amount of *Cordyceps* mycelia (Li et al., 1991, 2004a). During the fermentation of *Cordyceps*, the level of ergosterol changed according to the time of culture; a steady level of ergosterol was revealed when the maturation of *Cordyceps* mycelia was reached (Fig. 4).

![Fig. 4. The amount of ergosterol changes according to the growth of Cordyceps. A cultured Cordyceps (Li and Tsim, 2004) was tested under different days of fermentation. Ergosterol was revealed by HPLC (Li et al., 2004a) and mean values of five determinations are presented. The SEM is less than 5% of the mean, which is not shown for clarity.](image-url)

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Pharmacological study showed that petroleum extract of *Cordyceps*, rich of ergosterol, possessed anti-arrhythmia effect (Li et al., 2000). The derivatives of ergosterol have been isolated from the methanol extract of *C. sinensis*, which have been shown to have anti-tumor properties (Bok et al., 1999; Lin et al., 1999). In addition, the ergosterol derivatives also have multiple pharmacological activities, such as cytotoxic activity (Nam et al., 2001) and anti-viral activity (Lindequist et al., 1989); these activities are in line with the quality of *Cordyceps* for both natural or cultured products. Therefore, the level of ergosterol is a useful marker for quality control of *Cordyceps*, at least which represents part of *Cordyceps*’ biological functions.

**Mannitol is a marker for cultured Cordyceps**

D-Mannitol is one of the major active compounds in natural *Cordyceps*, and which contributes over 3.4% of the total dry weight. Mannitol has shown to have diuretic, antitussive and anti-free radical activities (Li et al., 1999a). Mannitol is being used to treat many diseases, and therefore which has been used as a marker for *Cordyceps* (Shen and Zhou, 1997). The content of mannitol in *Cordyceps* was usually determined using volumetry, or thin layer chromatography scanning, or colorimetry (Li et al., 1999a). HPLC analysis showed that mannitol was the major component of carbohydrate in natural *Cordyceps*, and the content of mannitol in natural *Cordyceps* was higher than that in the cultured one (Li et al., 1999b). The content of mannitol determined by HPLC is much lower than that determined by other methods, which could be the HPLC analysis avoids the signals generated from the reduced monosaccharides.

**Polysaccharide represents the most biological properties of Cordyceps**

*Cordyceps* contains high amount of polysaccharide, which could be ranged from 3 to 8% of the total dry weight (Li et al., 1999b, 2003). *Cordyceps* polysaccharide is considered to process the activities of anti-oxidation (Yamaguchi et al., 2000; Li et al., 2002), immunopotentiation (Liu et al., 1992; Xu et al., 1992; Li and Tsim, 2004), anti-tumor (Zhang et al., 2004) and hypoglycemic (Kiho et al., 1999). Until now, the pharmacological profile of *Cordyceps* correlates very well with the amount of polysaccharide in the herb. Based on the binding to Mono Q column, four fractions of polysaccharides were isolated from different types of natural and cultured *Cordyceps*; however, the ratio of these four polysaccharide fractions varied in different cultured products of *Cordyceps* (Li et al., 1999 a, b). The molecular weights of polysaccharides isolated from *Cordyceps* were also compared by gel filtration. The polysaccharides in natural *Cordyceps* were predominantly (> 50%) those high molecular weight molecules of over 150 kDa, which were rather distinct as compared to the cultured products.

Based on the activity-guided fractionation, a water soluble protein-containing galactomannan was isolated from the sodium carbonate extract of *Cordyceps*, and its molecular weight was estimated by gel filtration to be ~23 kDa. The isolated compound composed of D-mannose and D-galactose in a molar ratio of 3 : 5, and contained a small proportion of protein. It is a highly branched structure and composes of (1→6)-and (1→2)-linked α-D-mannopyranosyl residues in the main chain (Kiho et al., 1986). Another polysaccharide with hypoglycemic activity, purified from a hot water extract of the cultured mycelium of *C. sinensis*, was a combination of galactose, glucose and mannose in a molar ration of 43 : 33 : 24; its molecular weight was estimated to be about 15 kDa (Kiho et al., 1999).

In searching for active component(s) of having anti-oxidating activity from cultured *Cordyceps*, a polysaccharide of molecular weight ~210 kDa, named CSP-I, was isolated from cultured *Cordyceps* mycelia by ion-exchange and sizing chromatography (Li et al., 2003). The isolated polysaccharide, having strong anti-oxidating activity, contained glucose, mannose and galactose in a ratio of 1 : 0.6 : 0.75. The pre-treatment of isolated polysaccharide on
cultured rat pheochromocytoma PC12 cells showed strong protective effect against hydrogen peroxide (H₂O₂)-induced insult. This report identified a polysaccharide from Cordyceps that protected against the free radical-induced neuronal cell toxicity.

Future prospectus

Because of the decreasing supply of natural Cordyceps, the isolation of mycelial strain from Cordyceps is a trend of many scientists in Orient to achieve a large scale production of Cordyceps by fermentation. Indeed, the current health food market is full of fermented products of Cordyceps; however, many of them are adulterants. The methodology for authentication of these products has to be well defined, and chemical markers are needed for quality control. Although many so-called active constituents have been identified, the exact roles of these chemicals for the functions of Cordyceps are not known. At present, multiple markers such as ergosterol, nucleoside, mannitol and polysaccharide are being used for quality control of Cordyceps' products. Unfortunately, these markers are far from optimization, and extensive works are needed to define the pharmacological efficiency of these chemical markers.

Another approach in quality control of the herb is using chemical profiling instead of a single compound. By capillary electrophoresis, distinct fingerprints could be revealed in water-soluble constituents derived from different sources of Cordyceps (Li et al., 2004b). The result shows that those samples of natural Cordyceps are resemblance to each other in the fingerprinting, which are in distinction to the cultured products. This method does not depend on the identities of any chemicals. Thus, the profiles generated from capillary electrophoresis could serve as fingerprints for the quality control of Cordyceps. With the needs of the health food market, the fingerprinting of having multi-markers, that represents different Cordyceps fractions, should be used for quality control of Cordyceps.

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