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Research Articles

Research Article

IN THE SEARCH OF END PRODUCTS OF COMMERCIALLY IMPORTANT MEDICINAL PLANTS: A CASE STUDY OF YARSAGUMBA *(Ophiocordyceps sinensis)* AND BISH *(Aconitum spicatum)*

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ABSTRACT

Knowledge of end products of medicinal plants and their consumption can be useful for predicting future demand and planning for sustainable harvesting. In this context, a survey was carried out in July 2016 to March 2017 in Nepal and India to explore the industrial demand of commercially important medicinal plants such as *Neopicrorhiza scrophulariiflora, Ophiocordyceps sinensis* and *Aconitum spicatum*, their end products and uses. This paper presents case studies of *Ophiocordyceps sinensis* and *Aconitum spicatum*. The study findings showed that four industries processed 10 kg *O. sinensis* in a year (2015/016), and produced four types of end products such as Ayurvedic tonic, food supplement, alcoholic beverage and sex stimulant tea. No industry was found processing *A. spicatum* in Nepal. The end products containing *O. sinensis* were reported having multiple benefits to human body including enhancing immunity power, boosting stamina, inducing relaxation, providing energy and mental freshness and healing a number of health disorders. The domestic industrial consumption of *O. sinensis* was found insignificant in comparison to its harvested volume in trade, and should not be considered a major threat to this species. Diversification of end products of *O. sinensis* is recommended to contribute to national economy while promoting consumer healthcare in Nepal.

Key words: medicinal plant, herbal manufacturing industries, end products, Nepal

INTRODUCTION

Dependency of people on the medicinal plant products for healthcare is not recent and it is unlikely to decrease in the foreseeable future (Smith-Hall et al., 2012; WHO, 2001). It is increasingly documented that people in developing countries resort to parallel treatments with traditional and allopathic medicine and that the choice is pragmatic rather than cultural (Smith-Hall et al., 2012). In both years 2001 and 2002, approximately one quarter of the best-selling medicines worldwide were natural products or their derivatives (Butler, 2004).

Thousands of species of higher plants are used in traditional and modern medicine throughout the world, and many more species are important to the growing market for plant-based cosmetics, essential oils, food, beverages and other products, representing by far the biggest use of the natural world in terms of number of species (Sharrock et al., 2014). The international and domestic trade of medicinal plants is expanding. There is a substantial annual trade in alpine and sub-alpine medicinal plant products harvested in the wild throughout Nepal (Olsen, 1998; Edwards, 1996). On the one side, the annual value of trade amounts to millions of US dollars, and on the other side, traders and processors in India predict a rising demand for Himalayan medicinal plant products (Olsen, 1998). The global demand of herbal medicine is growing and its market is rapidly expanding annually in India (Subrat, 2002). Industries process these raw medicinal plants and produce end products for end consumers. These products are supplied in domestic and international markets for consumption. Increased attention to medicinal plant consumption and its dynamics may contribute to the development of collaboration across the natural resources and health sectors, resulting in more comprehensive and efficient health policies (Smith-Hall et al., 2012). We currently have no knowledge on what drives this consumption.

Medicinal plants harvested in Nepal are highly exported mainly to China and India besides domestic consumption. Consumption of processed end products of medicinal plants is common among people of developing countries (Srivastava et al., 1996). This consumption can have major influence on the long term demand and trade levels of these products. The information on what are the end products and what drives the consumption of those end products may be useful for prediction of future demand of the species and trade

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levels, planning for harvesting sustainability, species conservation and appropriate policy formulation. The formulation of sound and functional health, trade and conservation policies aimed at securing the well-being of poor populations and conservation of species need an understanding on the determinants of the demand. But at present, we do not have information on industrial demand and consumer products of highly traded medicinal plants, their consumers and consumption pattern. In this context, this study aimed to contribute in understanding the consumption of the end uses of highly traded medicinal plants by exploring the industrial demand and end products of *Ophiocordyceps sinensis* and *Aconitum spicatum* and their uses in Nepal. These species are introduced in the following section:

Species introduction

Ophiocordyceps sinensis is a medicinal herb found in subalpine and alpine Himalayan pastures between 3400-500 masl in Nepal, Bhutan, Tibet and India (Winkler, 2008; Shrestha and Bawa, 2013; He, 2018). It consists of the fruiting body of a parasitic fungus (*O. sinensis*) and its host caterpillar, the alpine ghost moth of the genus Thitarodes. It is called the caterpillar fungus/mushroom in English, Yartsa Gunbu (winter worm-summer grass) in Tibet, and Yarsagumba in Nepal. The fungus is believed to enhance energy and vitality, strengthen lung and kidneys, stop hemorrhage, decrease phlegm, and heal tumor and aging (Holliday and Cleaver, 2008). It is widely traded as an aphrodisiac and a powerful tonic (Holliday and Cleaver, 2008; Winkler, 2009; Shrestha and Bawa, 2013) and is considered as the single-most expensive raw material used in Oriental Medicine around the world (Holliday & Cleaver, 2008). The abundance of *O. sinensis* is significantly affected by vegetation composition, whereas the individual fungal traits were independent of soil nutrients or vegetation composition in Dolpa region of west Nepal (Sigdel et al., 2017). It is threatened by intensive collection, habitat loss and degradation, and climate change (Shrestha and Bawa, 2013). The understanding of the end uses of *O. sinensis* is limited in Nepal. In particular, there is a lack of information on the end products of *O. sinensis* and industrial demand in Nepal, which is one of its world's largest production areas of this species.

Aconitum spicatum is a poisonous herb belonging to family Ranunculaceae. *A. spicatum* grows in moisture retentive but well-draining soils of mountain meadows. It is highly toxic, so its tubers are used in medicine systems only after proper processing (Singhuber et al., 2009). The toxicity of *A. spicatum* mainly derives from the diester diterpene alkaloids (Shyaula, 2011). Besides diterpenoid alkaloids, other various alkaloids like higenamine, coryneine, lipohypaconite, lipodeoxyaconitine, lipoaconitine and benzyl mesaconine are also reported from *A. spicatum* (Kimura et al., 1988; Atta-ur-Rahman & Ahmad, 1990). Recently, bioactivities of some new diterpenoid alkaloids have been reported from genus *Aconitum* (Yuan & Wang, 2012; Guo et al., 2014; Yin et al., 2014). *A. spicatum* is one of the highly valued medicinal plants, which is in trade from Nepal to India in a huge quantity (Olsen, 1998). It is well known to the ancients as a powerful poison, but was the first employed as a medicine by Baron Storck, of Vienna, whose experiments were published in the year 1762 (Harvey et al., 1898 in Shyaula, 2011).

MATERIALS AND METHODS

Selection of focal species

First of all, three medicinal plant species of Nepal were selected as focal species for this study. The criteria for selection were high level of trade and current information gap. Two species highly traded to India: *Neopicrorhiza scrophulariiflora* (Pennell) D. Y. Hong (hereinafter referred as *N. scrophulariiflora)* and *Aconitum spicatum* (Bruhl) Stapf (hereinafter referred as *A. spicatum)* were selected. One species highly traded to China: *Ophiocordyceps sinensis* (Berk.) G. H. Sung, J. M. Sung, Hywel-Jones & Spatafora (syn. *Cordyceps sinensis* Berk.) (hereinafter referred as *O. sinensis*) was selected. These three species are referred as 'focal species' hereinafter. End products of *O. sinensis* are unknown and understanding of its demand drivers is particularly important (Pouliot et al., 2018). The bulk of high-altitude exports from Nepal to India comprised eight alpine and sub-alpine medicinal and aromatic plant species (*Aconitum heterophyllum* Wall. ex Royle, *Aconitum spicatum* (Brühl) Stapf, *Bergenia* species, *Dioscorea deltoidea* Wall. ex Griseb., *Morchella* species., *Nardostachys grandiflora* DC, *Neopicrorhiza scrophulariiflora* (Pennell) D. Y. Hong, and *Rheum australe* D. Don) and one mineral (Larsen and Smith, 2004). Information on end products of these focal species is also not available in scientific literatures, except of *N. scrophulariiflora* (see Kafle et al. 2018 for latest research findings).

Trader survey in India

In July 2016, a survey was done in three cities namely Tanakpur, Haridwar and Delhi of India where markets of exported medicinal plants of Nepal exist. Major traders (regional wholesalers) were interviewed in Tanakpur (n=4), in Haridwar (n=1) and in Khari Baoli of Delhi (n=4) and asked where they supplied the focal species (*N. scrophulariiflora, O. sinensis* and *A. spicatum*) in 2015/016 that were bought from Nepal. This survey went simultaneously with Regional Wholesaler survey (RWS) for trade of medicinal and aromatic plants in India; the RWS was guided by Smith-Hall et al. (2018).

Inventory of herbal manufacturing industries and telephone survey

The resistance to response from Indian traders on supply chain of focal species imported from Nepal led to planning for survey in Nepal. Since the updated list of functional herbal manufacturing industries in Nepal was missing, a list comprising of 246 herbal manufacturing industries in Nepal was compiled during September-November 2016 through a separate survey. Representatives from those herbal manufacturing industries were interviewed through telephone call to identify whether they process focal species or not. Lists of industries manufacturing end products from focal species were prepared with their contact details.

Market survey

A market survey was also conducted where 2313 herbal products were randomly checked for focal species as ingredients, in two big cities: Kathmandu and Bharatpur of Nepal, during November-December 2016. 1286 herbal products were surveyed in Kathmandu city in 30 shops and 1027 herbal products in eight retailer shops of Bharatpur city in Chitwan district of Nepal.

Industrial survey

An industrial survey was conducted among manufacturing industries using the focal species in order to know mainly about the end products containing the focal species, and demand and availability of unprocessed focal species for production of those end products during January-March 2017. Face to face interviews were conducted with representatives of these industries using structured questionnaire. The information on end-products collected from market survey was also cross-checked and validated with this survey. This paper presents case studies of only *O. sinensis* and *A. spicatum*. The case study of *N. scrophulariiflora* is presented in detail in Kafle et al. (2018) which reported twenty three industries processing *N. scrophulariiflora* with other medicinal plants in producing 45 Ayurvedic medicines in Nepal.

Respondents were informed about the purpose of the research and their prior consent was obtained for interview. The research did not require approval of ethics from government of Nepal since it was a pure academic research mainly based on non-invasive and non-destructive methods (i.e. interviews). Data analysis was performed using MS Excel. Descriptive statistics including frequency, percentage, mean, sum, average were used. The information were presented in tables and explained/analyzed. In this paper, the case studies of *O. sinensis* and *A. spicatum* are presented in detail.

RESULTS AND DISCUSSION

Supply chain of unprocessed *O. sinensis* and *A. spicatum* from traders in India

The demand for plant based medicines, health products, pharmaceuticals, food supplement, cosmetics etc. are increasing in both developing and developed countries (Kala, 2006), due to the growing recognition that the natural products are non-toxic, have less side effects and easily available at affordable prices. The traders reported that *O. sinensis* and *A. spicatum* are not traded at all from Nepal. Out of three focal species, only *N. scrophulariiflora* originated in Nepal was traded among other medicinal plant species. They resisted answering where they supply *Neopicrorhiza,* indicating their business privacy. Much of the Nepal-China trade of medicinal plants is extra-legal as a result of weak monitoring on both sides of the border and the value chain is thus governed by both legal and extra-legal mechanisms (He et al., 2018). Similar extra-legal trade of medicinal plants between Nepal-India was indicated in previous studies e.g. Olsen and Helles (1997). Subedi et al. (2013) reported the existence of illegal trade of wild orchids from Nepal to India, China and Hong Kong. The extra-legal trade can be one of the major reasons that the Indian traders were opposing to expose their trade networks or supply chains.

Manufacturing industries of *O. sinensis* and *A. spicatum* in Nepal

Out of 246 herbal manufacturing industries, no industry was found processing *A. spicatum* in Nepal. According to industrial respondents, *A. heterophyllum* is mainly used for preparing Ayurvedic medicines in Nepal but not *A. spicatum*. Both species (*A. spicatum* and *A. heterophyllum*) might be traded under common trade name Bish Jara to manufacturing industries in Nepal.

Out of 246 herbal industries, a total of four industries (1.62%) were found processing *O. sinensis* in Nepal to manufacture its end-products, which is lesser than *N. scrophulariiflora*-processing industries in Nepal (n=23, 9.34%, Kafle et al. (2018)). Out of four *O. sinensis*-processing industries, two were in province number 3 (Kathmandu), one in province number 1 (Tehrathum) and one in province number 4 (Gorkha). No *O. sinensis*-processing industries were recorded in province numbers 2, 5, 7 and Karnali province. Three *O. sinensis*-processing industries were privately owned and one was government-owned. The legal trade of *O. sinensis* started in Nepal after 2001. The government of Nepal shifted its emphasis on growth from the public to the private sector according to the Industrial Enterprises Act of 1974 and its frequent amendments. Nepal entered into multiparty democratic system in 1990 after a nationwide successful revolution, which created for private sector development in the country, including industries. Pyakurel et al. (2018) reported that there were no processing industries for medicinal and aromatic plants in Darchula district in far west Nepal, despite high levels of annual trade (401 tons in 2014-015). Infancy stage of herbal processing and manufacturing in Nepal was indicated by Edwards (1996) projecting the difficulty to compete with India's large herbal processing operations. How to create conducive environment for growth of manufacturing industries for high value medicinal plants within the country should be one of the national priorities in Nepal.

Domestic industrial consumption (volume) of *O. sinensis* in Nepal

Plants have been utilized for medicines and herbal products for thousands of years (Smith-Hall et al. 2012). In fiscal year 2015/016, we found that the four *O. sinensis*-processing industries consumed 10 kg unprocessed *O. sinensis* in a year to produce its end products in Nepal. The demand for *O. sinensis* ranged from 1 to 5 kg per year, with average 2.5 kg per year per industry. We discussed this less amount of domestic industrial consumption of *O. sinensis* in Nepal by taking reference of Pouliot et al. (2018) which reported 384.1 kg annual supply from Darchula district of western Nepal alone in 2014-015. Shrestha and Bawa (2013) quantified 1170.8 kg trade of *O. sinensis* in 2011 from Dolpa district of western Nepal. The lower levels of domestic industrial consumption can be referred to less number of herbal manufacturing industries and preference of trade of unprocessed *O. sinensis* due to high value in unprocessed form. Pouliot et al. (2018) reported that unprocessed *O. sinensis* is airlifted by central wholesalers from Kathmandu to regional wholesalers in China, with Lhasa, Kunming, Guangzhou, and Beijing as important destinations. *O. sinensis* is top six species traded from Nepal to China by traded volume and value with USD 1, 00,000 per kg price in Tibet. In many cases, Chinese regional wholesalers travel to Katmandu to buy *O. sinensis* directly from central wholesalers and themselves carry weights of between 5-10 kg of the product back to China (He et al., 2018). High value of *O. sinensis* in unprocessed form and suitability for consumption in raw form might be the reasons for low level of processing by few domestic industries in Nepal. The Industrial Policy of Nepal came into effect only in 2010 that identified priority industries for Nepal, including forest based industries and Ayurvedic and homeopathic medicine manufacturing, as priority industries, that clearly indicates infancy of herbal industries in Nepal.

Availability of *O. sinensis* for industries and its substitutes in Nepal

In Nepal, large-scale collection involving tens of thousands of harvesters began after the ban on collection and trade of *O. sinensis* was lifted in 2001 (Shrestha & Bawa, 2013). All the respondents reported that their industries had not faced any difficulty in obtaining quality *O. sinensis* to fulfill their annual demand. They did not depend on single trader to obtain raw *O. sinensis*. Price and quality played important role in choosing the traders. They used to look the samples to confirm the desired quality and negotiated price with the trader for purchase. Sometimes, they used to contact the traders asking for required quantity of *O. sinensis*, sometimes traders themselves contacted to industries to ask whether they need the *O. sinensis*. All the *O. sinensis*-processing industries did not use any substitute for this species, indicating that their demand were easily fulfilled and no other species is comparable to *O. sinensis* in terms of its value, popularity and perceived effectiveness; they did not require large quantities of *O. sinensis* annually, and in most of the

products, *O. sinensis* was only used as an ingredient in end-products.

Harvesting of *O. sinensis* is one of the key income sources of local people at mountainous areas of Nepal. Income from *O. sinensis* accounted for up to 65% of the total household cash income, on average, and its contribution was highest in the poorest households in Jumla district of western Nepal (Shrestha et al., 2017). Shrestha and Bawa (2013) analyzed the harvesters' perceptions of abundance of sustainability of *O. sinensis* in Dolpa district of Nepal that showed that virtually all harvesters (95.1%) believe the availability of the caterpillar fungus in the pastures to be declining, and 67% consider current harvesting practices to be unsustainable. Per-capita harvest of *O. sinensis* based on the first day of collection has declined over the last four years, apparently because of the decline in the stock and the increasing number of harvesters (Shrestha et al., 2014). Despite this, *O. sinensis*-processing industries of Nepal easily obtained required quantities due to less demand and fewer industries.

End products of *O. sinensis* and their uses in Nepal

Natural products, and particularly medicinal plants, remain an important source of new medicines, new drug leads and new chemical entities (NCEs) (Newman et al., 2003; Butler, 2004). Multiple uses of unprocessed *O. sinensis* have been recorded. However, less attention has been paid to its conservation and sustainable use (Dahlberg, 2001) and its end products. The *O. sinensis* has been used traditionally, but not exclusively, for decades to design various pharmaceutical products and their derivatives (Winkler, 2008). In case of Nepal, we do have dearth of similar researches so, we did not have prior information/ data/knowledge about the end-products manufactured from *O. sinensis*. Medicinal products of *O. sinensis* origin are not commercially available and not commonly used in Nepal, even today (Baral et al., 2015). Our study shows that *O. sinensis* was used for manufacturing only four herbal products in Nepal. A complete list of end-products containing *O. sinensis* is presented in Table 1 with description. Out of four end products, *O. sinensis* was used as an ingredient in three products: Special Chyavanaparasha Avaleha, Yarsa Wine and Power Tea. The sole product containing only *O. sinensis* was Sanjiwani Cordyceps Capsule. The forms of these medicines were different: one in gel form, one in capsule form, one in liquid form and one in powder form. It shows that diversification of end products of *O. sinensis* is in infancy stage in Nepal. In this context, we did not conduct consumer surveys of end products of *O. sinensis* in Nepal.

Table 1. End products containing *O. sinensis* with their processing industries, consumption, uses and production rank in 2015/16

End product containing *O. sinensis*	Form	Number of processing industries	Consumption of dry and unprocessed *O. sinensis* (kg/year)	Category of product	Use	Rank of production
Special Chyavanaparasha Avaleha	Gel	1	2	Ayurvedic tonic	Complete rejuvenative and nutritive Ayurvedic tonic useful in Cough, Cold, Asthma, Anemia, Loss of Libido and General Debility	1
Sanjiwani Cordyceps Capsule	Capsule	1	5	Food supplement	Enhances immunity power of the body, boosts stamina, treats weakness, provides energy, gives mental freshness	2
Yarsa Wine	Liquid	1	1	Alcoholic beverage	Induces relaxation	3
Power Tea	Powder	1	2	Sex stimulant tea	Enhances sexual power, increases the immunity power	4

The annual consumption of dry *O. sinensis* for production of Sanjiwani Cordyceps Capsule was recorded as the highest (5 kg). The annual consumption of dry *O. sinensis* for production of particular end-product containing *O. sinensis* ranged from 1 to 5 kg. The average annual consumption of dry *O. sinensis* for production of end product is 2.5 kg per industry. Processing of *O. sinensis* to produce consumer products by herbal manufacturing industries is not found in priority in Nepal. Natural products discovered from medicinal plants (and derivatives thereof) have provided numerous clinically used medicines. Even with all the challenges facing drug discovery from medicinal plants, natural products isolated from medicinal plants can be predicted to remain an essential component in the search for new medicines (Balunas and Kinghorm, 2005). *O. sinensis* has been used in Traditional Chinese Medicine (TCM) for at least 2,000 years (Shrestha et al., 2010). The hand-collected caterpillar-fungus complex is valued by herbalists as a source of libido and a genuine specimen is used as an aphrodisiac and also as an elixir (Winkler, 2009). We observed that Power Tea contains *O. sinensis* as an ingredient with other medicinal plants such as *Mucuna pruriens, Chlorophytum borivilianum, Asparagus racemosus, Withania somnifera, Amomum subulatum, Tinospora cordifolia, Cinnamomum tamala* and *Euphorbia hirta*. The tea is a sexual power enhancing herbal tea. This tea is believed to enrich new vigor and vitality in body to perform well and satisfactorily. Besides it is believed that it eliminates any type of sexual debility making human strong from inside. In addition, the industrial respondent reported that it will also increase the immunity power. Nevertheless, the major trade of *O. sinensis* occurs with the popular name ''Himalayan Viagra'' for use as an aphrodisiac and tonic (Holliday and Cleaver, 2008; Winkler, 2009).

Potential pharmaceutical uses of *O. sinensis* are available in Baral et al. (2015). Sanjiwani Cordyceps Capsule is reported to be an ideal and superior nourishing product to boost immune system and stamina. According to the industrial respondent, it can promote metabolism, improve cardiac muscle nutrition, and enhance boost immunity, so it's good for the middle aged and elders. It is believed to treat well on nervous breakdown, in appetite, and malnourished. With a special effect in the treatment of cardiac arrhythmia, it is believed to protect the heart. It is reported effective in raising the exercise tolerance, improvement in sleep and appetite and enhancing the body's immunity. According to the respondent, no toxic and side effects have been observed even after prolonged application. It is cooked with pork, sparrow and turtle to treat fatigue (Miller, 2009). Potentiality of *O. sinensis* to increase stamina and libido is mentioned by a number of authors (Holliday and Cleaver, 2008; Baral et al., 2015). Benefits of *O. sinensis* in blood circulation and stabilization of blood sugar metabolism were discussed in a number of papers (Winkler, 2008; Zhou et al., 2008). *O. sinensis* was also found beneficial in treating coughs, preventing cardiac arrhythmias, heart and liver diseases (Pelleg and Porter, 1990). Approximately 60% of anticancer compounds and 75% of drugs for infectious diseases are either natural products or natural product derivatives (Newman et al., 2003).

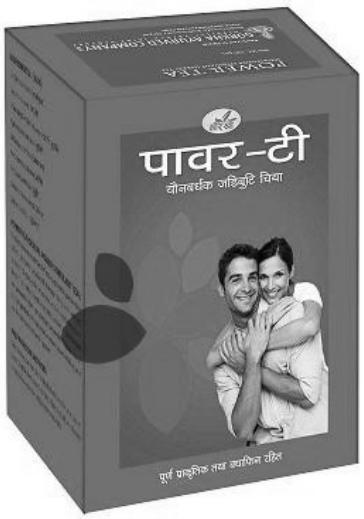

Figure 1: Power Tea containing *O. sinensis* as an ingredient

Figure 2: Sanjiwani Cordyceps Capsules

Because of its highly nutritive and medicinal properties, *O. sinensis* is considered as the single-most expensive raw material used in oriental medicine around the world (Holliday and Cleaver, 2008). In this research, Special Chyavanaparasha Avaleha is reported to be a complete rejuvenative and nutritive Ayurvedic

tonic. It is reported to be useful in cough, cold, asthma, anemia, loss of libido and general debility. It includes also other ingredients like *Dactylorhiza hatagirea, Mucuna pruriens, Phyllanthus emblica, Dashmoola, Ashtavarga, Piper longum, Elettaria cardamomum* etc. Devkota (2006) reported that indigenous peoples of Dolpa district of western Nepal are utilizing *O. sinensis* for the treatment of different diseases like diarrhea, headache, cough, rheumatism, liver disease, and also as an aphrodisiac and tonic. Therapeutically, it is used to strengthen lung and kidneys, increase energy and vitality, stop hemorrhage and decrease phlegm (Holliday and Cleaver, 2008).

O. sinensis has been used since historical times for healthcare purposes for example, to treat sexual dysfunction (Liu et al., 1997), to treat high lipid and cholesterol in blood (Francia et al., 1999), as an antioxidant (Li et al., 2001), hypoglycemic (Zhang et al., 2006), to treat fatigue (Miller, 2009) etc. In this study, Yarsa Wine is reported to improve mental health, enhance heart health, boost immunity and induces relaxation. However, it needs clinical investigation and verification.

Figure 3: Special Chyavanaparasha Avaleha containing *O. sinensis* as an ingredient

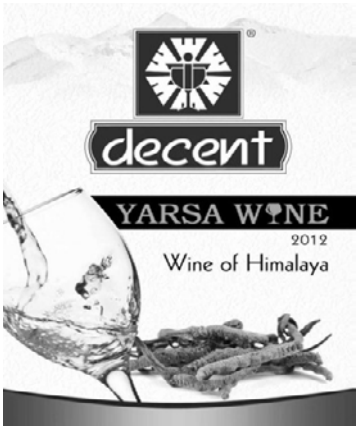

Figure 4: Yarsa Wine containing *O. sinensis* as an ingredient

CONCLUSION

This research explored the end uses of *Ophiocordyceps sinensis* and *Aconitum spicatum* in Nepal for the first time. The end products of *O. sinensis* comprise Ayurvedic tonic, food supplement, alcoholic beverage and sex stimulant tea, with multiple uses including enhancing immunity power, boosting stamina, inducing relaxation, providing energy and mental freshness and healing a number of health disorders. Like the case of *N. scrophulariiflora*, the domestic industrial consumption is not the cause of resource depletion of *O. sinensis* in Nepal. Diversification of end products of *O. sinensis* is needed to promote consumer healthcare and boosting national economy in Nepal. The empowerment of herbal manufacturing industries, especially in terms of processing technology and market development of end products of *O. sinensis* is recommended. Similar study is needed to understand the industrial consumption and end uses of *O. sinensis* in other countries like China where this species is traded in large volumes from Nepal. The regulation of harvesting and export of *O. sinensis* is necessary for wise use and sustainable management of *O. sinensis* in Nepal. For this, regional cooperation among its source countries is imperative.

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