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Trade potentiality of oils extracted from *Prunus davidiana* (wild apricot), *Sapindus mukorossi* (soapnut) and *Zanthoxylum armatum* (Nepalese pepper) in Kailash Sacred Landscape, Nepal

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ABSTRACT

Currently, 80–90% of Nepalese medicinal and aromatic plants (MAPs) are exported in crude form to more than 50 countries worldwide. The prospects of exporting processed MAPs have been discussed but the progress is slow. This paper analyses the trade and prospects of secondary processing of two vegetables oils, *Prunus davidiana* and *Sapindus mukorossi*, and an essential oil of *Zanthoxylum armatum* from Baitadi, Bajhang, Darchula and Humla Districts of the Kailash Sacred Landscape (KSL) in Nepal. A wide range of literature was referred and telephone interviews were conducted with traders and exporters to collect information on the trade value, volume and prospects of these three species. *Prunus davidiana* is a non-native species found in Humla District. *Prunus davidiana* oil is exported along with Chuli (*Prunus armeniaca*) oil with market price of USD 26/kg and an estimated export volume ranging around two tons in 2020 from Nepal. *Sapindus mukorossi* is cultivated and abundantly found in Baitadi, Darchula and Bajhang Districts. Crude *S. mukorossi* is one of the highly exported MAPs of Nepal (1,300–2,550 tons per annum) and from KSL Nepal (estimated 500 tons per annum), but the domestic trade and export of its oil is not yet commenced in the country. *Zanthoxylum armatum* is a widely cultivated native medicinal plant of Nepal with estimated annual export volume (crude) of 1,400–1,700 tons, KSL area in Nepal contributing 4–16 tons per annum. Zanthoxylum oil extracted from its fruits is exported to India and European countries. The market price of Zanthoxylum oil ranges between USD 110–130/kg, and the export volume ranged between 3.5–7.7 tons. There are no records of processing of Zanthoxylum oil in KSL Nepal. The prospects of *P. davidiana* oil in cosmetics and *S. mukorossi oil* in biofuel exists but few issues need to be addressed such as inclusion of *P. davidiana* in the Government of Nepal's royalty list to legalize the trade of its oil. Further research on yield and trade potential, and developing efficient processing technology are also needed to build on the trade potential of these three oils.

Introduction

Use of medicinal and aromatic plants (MAPs) is as old as humankind. The written history on the use of MAPs dates to almost 5000 years (Kelly, 2009). It has been estimated that 35,000 – 70,000 plant species are used for medicinal purposes by various cultures around the globe (Farnsworth and Soejarto, 1991). The official pharmacopeias also mention the use of more than 28,000 plant species for medicinal purposes (Willis, 2017). MAPs have high trade potentiality because of the growing interest of people in herbal medicines. It has been estimated that out of the total medicinal plants used globally, approximately 3000 species are in global trade (Schippmann et al., 2006). The global trade value of MAPs and its derivatives (including extracts, essential oils, phytopharmaceuticals, gums, spices used in medicine, tannins for pharmaceutical use, ingredients for cosmetics, etc.) was estimated at USD 33 billion in 2014 (Vasisht et al., 2016).

Nepal has a long history of MAPs trade that dates back to millennia (Dobremez, 1976). India and China were the two major importers of MAPs from Nepal in the past, but in recent years, the market has diversified, and Nepalese medicinal plants are now exported to more than 50 countries worldwide (Ghimire et al., 2016).

The export from Nepal is still dominated by unprocessed (crude) medicinal plants (Ghimire et al., 2016). The reasons speculated behind this include: (i) inadequate number of processing industries in Nepal; (ii)

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small market size in Nepal compared to neighbouring countries, causing increment in cost of production; (iii) as neighbouring countries produce in large volumes, their unit cost of production is lower and Nepalese herbal products are unable to compete with these cheap imports; and (iv) the preference of Indian importers for crude MAPs over processed products (Capporale et al., 2020; Kafle et al., 2018; Pyakurel et al., 2019). Thus, countries with a wide range of natural resources (including medicinal plants) but with limited economy should focus on niche products that have good market potential. Essential oils and vegetable seed oils are two such products for Nepal. Essential oils are aromatic and volatile natural oils typically obtained by steam distillation and having the characteristic odour of the plant or other source from which it is extracted (Rios 2016). Vegetable oils are oils extracted from seeds or other parts of fruits and are mixture of triglycerides (Thomas 2002). Essential oils worth USD 0.73 million were exported from Nepal in FY 2012/13 CE, whereas it increased to USD 7.7 million in FY 2020/21 CE (TEPC, 2013; 2021). In recent years, essential oils of both native and exotic medicinal plants are being produced in Nepal. Likewise, the market of vegetable oils is flourishing. Soyabean oil and Palm oil contribute to 38% of total export value for FY 2020/21 (TEPC, 2021) but the raw materials are imported. The amount of production and export of vegetable oils extracted from the Nepalese raw material, however, is not well documented.

There are considerable numbers of literature on domestic trade and export of Nepalese MAPs (Bista and Webb, 2006; Edwards, 1996; Olsen, 2005; Pyakurel et al., 2019; Singh et al., 1979) but relatively fewer on the use, domestic trade and export of oils of lesser to well-known plants e.g., *Prunus davidiana* (Carriere) Franch. (wild apricot), *Sapindus mukorossi* Gaertn. (soapnut) and *Zanthoxylum armatum* DC. (Nepalese pepper). This study provides a background for the trade, export and further development of seed oil production in Nepal. The objective of this paper is to document the domestic trade and export of wild apricot, soapnut and Nepalese pepper and their seed-derived oils from the Kailash Sacred Landscape area of Nepal.

Materials and methods

Study area

The Kailash Sacred Landscape (KSL) covers an area of 31,252 sq. km. and includes the South-Western part of the Tibet Autonomous Region (TAR) of China, contiguous areas of Western Nepal (Darchula, Baitadi, Bajhang and Humla Districts) and the North Eastern part of Uttarakhand, India (Fig. 1). The KSL is a historically, ecologically, environmentally and culturally important landscape (Pandey et al., 2016) and has unique biological diversity, value-based cultural heritage and some of the most revered and sacred landscapes in the world (Oli and Zomer, 2011). The KSL has a network of religious and sacred sites, high altitude lakes, snow peaks and permafrost areas (www.grida.no/resources/6679). The landscape is the origin of the Indus, Sutlej, Brahmaputra and Karnali Rivers that support the lives and livelihoods of millions of people and have a great significance for rangeland, wetland and forest ecosystems (Oli and Zomer, 2011).

MAPs and non-timber forest products are two of the major income generating sources for the people residing in the four districts of KSL Nepal, *viz* Baitadi, Bajhang and Darchula Districts in Sudurpashchim Province, and Humla District in Karnali Province. MAPs ranging from low to high valued and from mid hills to high mountains are naturally distributed in KSL Nepal (Table 1).

Methodology

The study method comprised literature review and telephonic interviews. The study reviewed research papers, policy documents and grey literature i.e., newspaper articles to estimate the production and trade of three species – both from KSL-Nepal and from Nepal. In order to achieve the comprehensive trade data of the selected three species, we expanded the empirically derived data with: (i) 12 years Hamro Ban (an annual publication of Department of Forest, Ministry of Forests and Environment, Government of Nepal) from fiscal year (FY) 2004/05 to 2015/16 CE and documented the trade of the three species (DoF, 2005 – 2017); (ii) products mentioned in the comprehensive review of literature in Smith-Hall et al. (2020); (iii) extensive literature search e.g., Google Scholar, Scopus, Web of Science, ResearchGate, Flora of India, Nepal's Floras and other reports (published and unpublished), and forestry legislations. We were unable to use the customs data because (i) the data is unavailable for specific products or species, and (ii) customs data only have the official export data but it has been observed that considerable volume of MAPs are exported bypassing the formal custom points.

The study was conceptualized during the COVID-19 lockdown period in Nepal and executed when the lockdown was partially lifted (September – November 2020) yet with continued threat of infection. Thus, face-to-face interviews with respondents were not conducted and telephonic surveys were administered instead to collect information. This method was very effective because when the respondents are scattered, they know the subject matter, information can be collected within a limited period of time, and hence it is very cost-effective (Musselwhite et al., 2007). The study identified three categories of respondents to document the trade: (i) local traders, (ii) central wholesalers, and (iii) processors. We adopted Olsen and Bhattarai (2005) for the typology of respondents. Local traders were located in or near the district of origin, were located in an average assemblage area of one to three districts, purchased from harvesters and sub-local traders and transported the products out of the district to central wholesalers' warehouse. Central wholesalers are located in the country of origin, have average assemblage area of two to six districts, and export medicinal plants out of the country of origin. Processors are engaged in processing and semi-processing of medicinal plants.

The name of the respondents was obtained from herbal associations, *viz*. Jadibuti Association of Nepal (JABAN), Nepal Herbs and Herbal Products Association, and Herbal Enterprise Association of Nepal. The database published by JABAN (2014) was also referred. A total of five traders, seven exporters and two processors were interviewed for this research. The interview focused on: (i) raw trade of three species from KSL-Nepal (i.e., four districts) and from Nepal; (ii) trade of Nepalese pepper oil, wild apricot oil and soapnut oil from KSL-Nepal and from Nepal; and (iii) issues and challenges of vegetable oil and essential oil trade.

For export volume estimation, we primarily relied on government data, or published and unpublished documents (e.g., for raw trade of soapnut, Nepalese pepper and trade of Zanthoxylum oil). In case of the unavailability of such data (e.g., for wild apricot oil) we used the responses of local traders and central wholesalers.

Results and discussion

Description of species

Prunus davidiana (Carriere) franch

Prunus davidiana (wild apricot) Khabu in Nepali, is a small deciduous tree upto 10 m with upright shoots, or shrub with weeping shoots, and a reddish-brown bark. The yellowish, spherical, downy fruit is about 3 cm in diameter and contains one large seed. Its fruit pit is small, hairy and its flesh is inedible. Flowering occurs between March – April; and fruiting between July – August (Bassi and Monet, 2008; Ohba et al., 2012; Polunin and Stainton, 1984).

It is domesticated in West and Central Nepal, almost semi-naturalized at altitudes between 2100–3400 m. It is generally found in forests, thickets, slopes, mountain valleys and waste fields (CDB, 2010; Ohba et al., 2012; Polunin and Stainton, 1984). It was documented from Mustang, Jajarkot and Humla Districts in domesticated condition. Being the similar geography and climate, it is assumed to be found in Bajhang

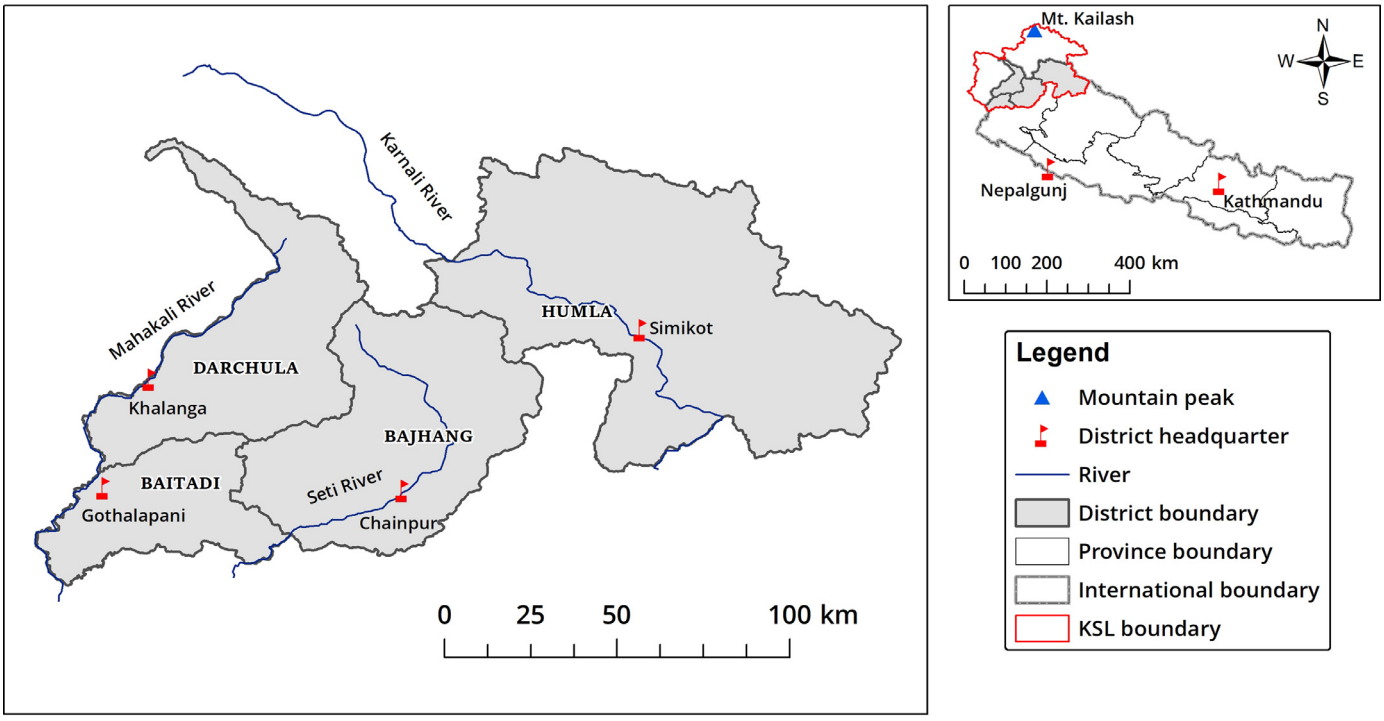

Fig. 1. Map of Kailash Sacred Landscape with the four districts of Nepal (Source: ICIMOD).

Table 1
Low to very high valued MAPs by altitudinal gradients in KSL-Nepal (names in parentheses denote common or Nepali names).

	Lower hills (<1000 m)	Mid and high hills (1000 – 3000 m)	High mountains (>3000 m)
Very high valued (More than NPR 10,000 per kg)		*Morchella esculenta* (Guchi chyau)	*Ophiocordyceps sinensis* (Yartsa-gunbu) *Fritillaria cirrhosa* (Kakoli)
High valued (NPR 2000 – 10,000 per kg)		*Ganoderma lucidum* (Rato chyau) *Delphinium denudatum* (Nirmasi) *Paris polyphylla* (Satuwa)	*Picrorhiza scrophulariiflora* (Kutki)
Mid valued (NPR 500 – 2000 per kg)	*Asparagus racemosus* (Kurilo)	*Zanthoxylum armatum* (Timur) *Valeriana jatamansi* (Samayo)	*Nardostachys jatamansi* (Jatamansi) *Brachycorythis obcordata* (Gamdol)
Low valued (below NPR 500 per kg)	*Acorus calamus* (Bojho) *Sapindus mukoroosi* (Rittha) *Cinnamomum tamala* (Tejpat) *Phyllanthus emblica* (Amala)	*Sapindus mukoroosi* (Rittha) *Cinnamomum tamala* (Tejpat) *Bergenia ciliata* (Pakhanved) *Berberis* spp. (Chutro) *Machilus odoratissima* (Kaulo) *Swertia chirayita* (Chiraito)	*Prunus davidiana* (Khabu)

Source: Pyakurel et al. (2017, 2018, 2019); Bista and Webb (2006).

and Darchula Districts. The highest altitude of occurrence of 3400 m was documented from Muchu of Humla District (CDB, 2010).

Zanthoxylum armatum DC

Zanthoxylum armatum (Nepalese pepper), Timur in Nepali, is a shrub or small tree reaching up to 5 m in height, with numerous long straight spines on branchlets and leafstalks. Ripe capsules are globular, red, wrinkled, and aromatic. The seeds, which are shiny-black with an aromatic husk, change to red in colour after maturity. Branchlet, leaves, and fruits are also aromatic. Flowering occurs in April-May and fruiting from July to November. Fruits take six to eight months to mature. (Polunin and Stainton, 1984).

It is distributed throughout Nepal within an altitudinal range of 1100–2500 m. It is distributed from Darchula in the west to Sankhuwasabha District in the east. Districts along the western Rapti River *viz*. Rolpa, Rukum, Salyan, Pyuthan, Dang are reservoirs of Nepalese pepper. Likewise, it is also found in larger areas of Surkhet, Gulmi, Baglung and Jajarkot Districts where commercial farming has also begun. Apart from these, far western districts like Darchula, Baitadi, Bajhang, Bajura, Accham, Dadeldhura are also known for Nepalese pepper.

All four KSL districts are known to have Nepalese pepper, with the least in Humla District because most of the areas of this district have upper temperate to nival climate and Nepalese pepper thrives below the mid-temperate climatic zone. Natural stands of Nepalese pepper are rare in Nepal, and most of the "wild" harvested fruits are from roadsides along the forest. Almost all the supply of Nepalese pepper are sourced from domesticated plants followed by commercial level cultivation.

Sapindus mukorossi Gaertn

Sapindus mukorossi (soapnut), Rittha in Nepali, is a deciduous tree, usually up to 12 m in height, sometimes attaining a height up to 20 m. Fruits are globose, fleshy, and about 1.8–2.5 cm across. Seeds 0.8–1.3 cm in diameter, and are globose, smooth, and black in colour. Flowering occurs during May-June. Bears fruits in July – August which ripen by November – December (Orwa et al., 2009; Singh and Ali, 2019).

In Nepal, *Sapindus mukorossi* is locally known as Rittha and grows in the lower foothills and mid-hills of the Himalayas up to altitudes of 900–1700 m. Soapnut trees are found in forests and farmlands mostly in

Sudurpashchim, Karnali and Lumbini Provinces. Darchula and Baitadi districts in Sudurpashchim Province are the reservoir for soapnut production with every household growing at least a couple of trees in their property (Pyakurel and Rijal, 2014). The soapnut trees begin producing fruits in 9-10 years and bear fruit for about 90 years. A single Rittha tree can produce 30–35 kg of fruit per year (Poudel, 2007).

Quantifying the trade volume and value

Seeds of *P. davidiana* and *S. mukorossi* yield vegetable oils which is used for medicinal purpose. Seed oil of *P. davidiana* is used for cooking and lighting (Rokaya et al., 2010); as a hair tonic (Ohba et al., 2012); and is applied to treat joint pains (CDB, 2010). Likewise, seed oil of *S. mukorossi* is used to treat skin wound and have anti-inflammatory and antimicrobial activities (Chen et al., 2019). The domestic trade and export of these vegetable oils is not properly documented in Nepal. However, there are numerous studies on the use, yield and trade of Zanthoxylum oil (essential oil extracted from the dried fruits of *Z. armatum*). This section sheds light on the trade and trade potentiality of vegetable oils of *P. davidiana* and *S. mukorossi* and essential oil of *Z. armatum*.

Trade of Prunus davidiana *(Carriere) Franch*

Quantification of trade of seeds and oils of *P. davidiana* for medicinal use is not properly documented in Nepal. The fruits are used for medicinal properties but not sold. Local residents collect the fruits from nearby areas generally for their personal use. A trader operating from Humla disclosed that he was engaged in purchasing wild apricot oil for a couple of years. The oil content is approximately 40% at the commercial level (personal communication on 27th October 2020). The price of wild apricot oil in September 2020 was USD 26 per kg. The oil, however, is extracted both from *P. armeniaca* and *P. davidiana*. Consultation with an exporter operating from Kathmandu said that their firm exported 1500 kg of apricot oil in fiscal year 2019/20 to Japan. The share of *P. armeniaca* and *P. davidiana* is about 60:40%. Likewise, another exporter from Kathmandu disclosed that their firm exported 500 kg of *P. armeniaca* and *P. davidiana* oil from Nepal in FY 2019/20. The total export value is estimated at USD 52,000. The individual share, of volume and value of export, however, was not disclosed as farmers collect both fruits and processors process them together. However, it can be conservatively estimated that share of *P. davidiana* to the total export of wild apricot oil is around 1200 kg.

We could not triangulate the data with other publications because trade of *P. davidiana* oil is not documented from Nepal. However, the telephonic interviews showed that there is possibility of commercial level trade and export of *P. davidiana* oil. The oils are used for cosmetic purpose and the trade potentiality exists as an exporter from Kathmandu disclosed that the demand of wild apricot from Japan is continuous and there are inquiries from South Korea also. We assume that till date, *P. davidiana* oil is exported using other names e.g., Khabu oil (*Prunus armeniaca*). Till date, *P. davidiana* is not included in the royalty list because the extraction of wild apricot oil is started recently. Thus, for the sustainability of export, *P. davidiana* should be included in the government royalty list so that wild apricot oil can be exported with its own name. A pilot scale resource inventory in high availability areas, such as Humla District, to estimate the annual production of seeds and oil is considered rational.

Trade of Zanthoxylum armatum *DC*

It is estimated that 1400–1700 tons of unprocessed Nepalese pepper fruits are annually traded in and from Nepal (DoF, 2005 – 2015; Olsen, 2005; consultation with exporters and traders on 24th October 2020) Caporale et al. (2020). estimated that 143–300 tons are annually processed to make essential oil (for export) and powder (to manufacture Ayurvedic and herbal preparations) in Nepal. Deducting the quantity consumed in the domestic consumed market, Nepal annually exports about 1100–1557 tons of unprocessed Nepalese pepper. With the average export price of Nepalese pepper in FY 2018/19 at USD 8/kg (ANSAB price list 2021, consultation with exporters of Nepalgunj on 24th September 2020), the export value of Nepalese pepper from Nepal is valued at USD 9.09–12.86 million.

The production of Nepalese pepper from Sudurpashchim Province is sporadic. In total, 25–30 tons of Nepalese pepper are annually traded from Sudurpashchim Province (DoF, 2005; Kala et al., 2003; Pyakurel et al., 2017, 2018). In contrast, 650–850 tons of Nepalese pepper are traded in and from Karnali proivince (Atullya Foundation, 2020; DoF, 2005–2015). The KSL have four districts - Baitadi, Bajhang, Darchula and Humla and the estimated production from these four districts ranged between 4– 16 tons DoF, 2005; Kala et al., 2003; Pyakurel et al., 2017, 2018).

Estimated 3000–7000 kg Zanthoxylum oil are annually exported from Nepal to India (consultation with Nepalgunj based processors/ exporters on 24th September 2021) till 2018. Patanjali, an Ayurvedic company based in Uttarakhand, was the major purchaser until 2018. Additional 500–700 kg oil were exported to European countries, USA and Japan until 2018. Thus, in 2018 alone, Zanthoxylum oil ranging between 3500–7700 kg were processed and exported from Nepal (JABAN, 2018). The average export price of Zanthoxylum oil ranged between USD 110–136 per kg within the periods of 2018–2020. Thus, the export value of Zanthoxyum oil in 2018 ranged between USD 0.39–1.07 million.

The market for Zanthoxylum oil decreased from 2019 onwards. With undisclosed reasons, the Indian importer (Patanjali) stopped the import of Zanthoxylum oil since 2019. The situation was further aggravated by COVID-19 resulting in further market shrinkage. Exporters from Nepalgunj and Kathmandu estimated that in 2020, the market would be limited to 500–1000 kg Zanthoxylum oil. There is very limited uptake of Zanthoxylum oil in the domestic market in Nepal. Only a few processors use the oil to manufacture herbal products (e.g., Sancho, herbal massage oil, etc.).

Despite the decrease in the export quantity of Zanthoxylum oil, there are prospects market diversification because the oil is now finding the market beyond India to the European countries where the oil is used as in ingredient of several cosmetic products. If the demand exists, then Nepal have the potential to produce 33–45 tons of Zanthoxylum oil on annual basis.

Trade of sapindus mukorossi *Gaertn*

S. mukorossi is one of the major traded medicinal plants in terms of volume of trade and dates to several centuries (Pyakurel et al., 2017). It has been estimated that 1300–2550 tons of raw *S. mukorossi* fruit are exported from Nepal (consultation with Nepalgunj based processors/ exporters on 24th September 2021; DoF, 2005–2015; Olsen, 2005;) to make soaps or detergents. The technological advancements and infrastructural development in western parts of Nepal have positive impact in trade of Rittha which is relatively low valued (Pyakurel et al., 2018). India is by far the major export destination where more than 95% of crude soapnut are exported, followed by European countries namely Germany and Denmark.

Caporale et al. (2020) estimated that 15–30 tons are annually processed to make soaps in Nepal. Deducting the domestic consumed quantity, Nepal annually exports 1285–2520 tons of soapnut. The average export price of soapnut in FY 2019/20 is USD 1.2/kg (ANSAB, 2021; consultation with Nepalgunj based processors/ exporters on 24th September 2020). Multiplying the estimated export volume with average price (received by exporters), the export value of soapnut is USD 1.56–3.07 million.

Sudurpashchim Province is the major production area for soapnut. It has been estimated that annually estimated 800–1000 tons soapnut are traded from Sudurpashchim Province (Pyakurel 2017, 18; DoF, 2015)

Likewise, it was assumed that 350–450 tons can be traded from Karnali Province (very few from Humla) (DoF 2005–2015). Based on these, we can conservatively estimate that estimated 500 tons are annually traded (domestic and export) from KSL-Nepal.

There are sporadic records of soapnut oil production in Nepal. In Gokuleshwor (Darchula District), a trader cum processor annually processed 200–600 kg of soapnut oil between 2016 and 2017. We consulted with five traders and two processors of Sudurpashchim Province and Nepalgunj and they unanimously stated that there is no production of soapnut oil in Sudurpashchim Province in recent years.

A consultation with a Nepalgunj-based exporter indicated that almost all Nepalese exporters export soapnut to India without removing the seeds. The demand of shells (without seeds) is very limited from India. However, from Europe most of the demand is for shells only. An exporter operating from Balaju, Kathmandu, said that he was involved in export of soapnut to Denmark for the last ten years. Currently he has 90 tons of soapnut seeds which has no use. He tested the different attributes of seed oil from laboratory at University of Minnesota, USA. At laboratory level, the oil yield was around 20–25%, the oil cake can be used as manure and seed as a source of fuel. Even he does not have any knowledge of trade of seed oil in and from Nepal. Thus, it can be considered that the production of soapnut oil is not commercially initiated in Nepal.

Soapnut kernel oil has been piloted to extract biofuel in India. The oil content of this species is comparable with similar tree seed oils, which have also been identified as promising source of biodiesel feedstock and falls within the existing biodiesel standards (Chakraborty and Baruah, 2013). Likewise, Chen et al. (2013) found that soapnut oil methyl esters (SNME) had satisfactory fuel properties and could be mixed with petrol as a biodiesel. These two evidences showed that though soapnut seeds are not used in Nepal till date, there is possibility of its utilization as biofuel and other commercial products.

Conclusion

Nepalese exporters are exporting wild apricot oil along with *Prunus armeniaca* oil. The export volume suggested that the trade of wild apricot oil is in nascent stage but can be expanded. A bureaucratic hurdle is that wild apricot is not included in the royalty list of Nepal. Thus, exporters have to use alternative name (e.g., *P. armeniaca*) for wild apricot. Inclusion of wild apricot in the royalty list is necessary to legalize and facilitate the trade. Likewise, research institutions should conduct research on efficient and affordable technologies for oil extraction so that the extraction machines can be located at rural areas for maximum efficacy.

It has been assumed that Nepal annually exported 1100–1557 tons of Nepalese pepper from Nepal. Likewise, 3.5–7.7 tons of Nepalese pepper oil are exported annually from Nepal to India and European countries. Nepalese pepper oil is a niche product of Nepal and has the potential to become one of the major herbal export commodities of Nepal. Research on low-cost-efficient technology for oil distillation and global marketing via participation in various herbal trade fairs is imperative.

Soapnut is another major exporting commodity of Nepal, and our study estimated the trade of 1300–2550 tons from Nepal. Presently, the seeds are discarded, hence extracting soapnut oil could reap additional profits from soapnut. Available records showed that the oil was produced once between 2016 and 2017, but commercial level oil extraction does not exist. Recognizing the potential international demand, soapnut oil could be another niche product for Nepal. Hence, there is a need to develop soapnut processing technology for commercial level oil extraction, and to link the product to the international market.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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