Culinary herbs and spices in Nepal: A review of their traditional uses, chemical constituents, and pharmacological activities

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Review

Background: Herbs and spices have long been used for both food and medicinal purposes in different world civilizations. In Nepal, various herbs and spices are used for culinary purposes. In addition, a range of bioactive compounds present in herbs and spices have been associated with multiple beneficial health properties. This paper aims to illustrate the diverse availability of traditional herbs and spices used in Nepali cuisine with their traditional uses along with their major phytochemicals and pharmacological activities.

Methods: Information related to traditional uses, chemical constituents and pharmacological activities were compiled from the published research articles, books, and book chapters.

Results: This study documented 50 herbs and spices with their traditional uses, the phytochemicals present and their medicinal application. Numerous bioactive compounds are reported such as polyphenols, quinines, organosulfur compounds, flavonoids, alkaloids, polypeptides, etc. and these compounds possess diverse pharmacological activities. These herbs and spices were primarily studied for their antimicrobial, anti-inflammatory, antioxidant, antidiabetic, antihyperlipidemic, hepatoprotective, and antipyretic activities.

Conclusion: The different scientific studies highlighted in this review suggest that most of the health effects of herbs and spices are observed on various chronic diseases, including cancer, cardiovascular diseases and diabetes. The antioxidant and anti-inflammatory properties of culinary herbs and spices can act to improve the overall health system. There are nutraceutical potentials that may open new opportunities for herb and spices-based enterprises.

Keywords: Spices, herbs, culinary, phytochemicals, medicine, health benefits

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Background

The history of herbs and spices is as long as the history of humankind. Since the very beginning, people have been using aromatic medicinal plants not only as flavoring agents for foods but also for their medicinal properties. Worldwide, more than 70% of the population still depends on medicinal plants and herbs as sources of primary health care (Devkota & Watanabe 2020). The phytochemicals isolated from plants have played a vital role in discovering and developing modern drugs (Atanasov *et al* 2021). These compounds are also used for numerous applications, including food preservatives, additives, coloring agents, etc. Moreover, medicinal, and aromatic plants are often found in several cosmetic products and perfumes (Aburjai *et al* 2003).

Nepal is well known for its geographical and cultural diversity, rich in traditional and indigenous knowledge, recipes, and resources. Herbs and spices have a prominent place in the Nepali cuisine, and they play a vital role in enhancing the flavor of the dishes (Eigner & Scholz 1999). Without these spices, the exotic flavors of Nepali foods do not come out. From ancient times, certain herbs and spices are used in daily cooking and adding a little spice to food makes any ordinary recipe taste good and exciting (Tapsell *et al* 2006). Spices are obtained from fresh or dried parts of plants in the form of bark, root, leaf, flower, seed, or fruit. These spices are used in a specific quantity as a flavor, color or as preservatives. Either addition or omission of species makes a significant change in the taste of the food we cook. Spices spice up our taste buds and come with tremendous nutritional values and health benefits.

In Nepal, many studies have focused on medicinal plants, including some herbs and spices. More than 700 plant species are reported to be used for their medicinal properties in Nepal and many are also used as spices (Manandhar 2002, Adhikari *et al* 2019, Kunwar *et al* 2010a, Kunwar *et al* 2010b). For example, Kunwar *et al* (2010b) surveyed the ethnomedicinal uses of different medicinal plants in far-west Nepal and reported their common uses in Ayurveda and the latest phytochemical findings with the pharmacological application. Similarly, a survey of medicinal plants including different spices was done and assessed the indigenous knowledge of uses and therapies with their pharmacological validity in Far west region of Nepal (Kunwar *et al* 2010b). Khanal *et al* (2013) studied nine Nepali kitchen spices, including clove, cinnamon, black pepper, cumin, coriander, fennel, long piper, and fenugreek for their antibacterial activity. Likewise, antioxidant activities of herbs and spices used in Nepali kitchen has been studied by Devkota *et. al* (2006). Although, a few studies have been performed on surveying and evaluating the properties of some medicinal plant of Nepal, including herbs and spices, there is a gap in utilizing traditional knowledge and integrating it with scientific evidence for the commercialization as a viable enterprise which can enhance the socio-economic development along with different health benefits. This is a flourishing field of study with respect to both health and economic point of view yet has been given less priority. Changing food habits and increasing demand on ethnic and natural ingredients for healthy living has increased the global market for traditional herbs, spices, and value-added products. Remarkably, now in the pandemic era, the importance of healthy lifestyle and food habits have been more important. There has been a lot of interest around the world in ways to maintain the health. The use of herbs and spices with antioxidant, anti-inflammatory, and antimicrobial properties has been increased worldwide and similar pattern is observed in Nepal too (Khadka *et al* 2021). So, in the present scenario, with the accelerated importance of herbs and spices, their nutraceutical and medicinal value should be explored in detail with their potential for utilization in development of various value-added products. Hence, in this paper, we report 50 most commonly used herbs and spices in Nepal along with their traditional uses, bioactive chemical constituents and pharmacological activities.

Traditional uses of herbs and spices

Herbs and spices have long been used as traditional ingredients in the kitchen to enhance the taste of food and for different health benefits. Besides, seasoning, coloring, aromatic and food preservative properties, herbs and spices are equally used for therapeutic purposes. Traditional medicine is based on ancient, natural healthcare practices like Ayurveda (Kunwar *et al* 2010a). People rely predominantly on such a health care system because of cultural acceptance, availability, affordability and beliefs. Herbs and spices consist of different plant parts primarily used in dried forms, whereas some, such as chili pepper, and ginger, are used in both their fresh and dried forms. Similarly, most of the spices are used in powdered forms, but some are used as whole seed, stem, and leaf. Diverse Nepali culture and geography have added unique variations and preparations of spices. The richness of Nepali cuisines and their diversity also reflects the wide varieties of herbs and spices. Spices like turmeric, cumin, coriander, ginger, garlic, onion, pepper, corm, fenugreek, and chili are primarily used in everyday Nepali cooking, whereas others are generally used occasionally way or in special festivals. In addition, these herbs and spices are used in a small amount in home-cooked foods (e.g., curries, rice, pickles, lentils, soup, etc.).

Every spice and herb has its unique application in both culinary and traditional medicines in Nepal. For example, turmeric is a popular spice that is dominantly used in every cooking as a coloring as well as flavoring agent. Among its various traditional uses, it is known for a wound healing quality along with its qualities against rheumatic disorders, gastrointestinal symptoms, deworming, and as a cosmetic (Devkota *et al* 2021). Similarly, ginger is known to help digestion, reduce nausea and act against flu and the common cold. Cumin powder is one of the most used spices in Nepali cuisine as a seasoning and it is considered that cumin seeds aid in digestion, improve immunity, and treat skin disorders. For centuries, cumin water has been used as a household remedy for digestive issues. Likewise, clove oil is used as a pain reliever, especially for toothaches. Cinnamon is a preferred spice for its flavor and is considered a remedy for gastric disorders. The details of the traditional uses as spice and traditional medicines of 50 most common herbs and spices are summarized in Table 1.

Bioactive chemical constituents of herbs and spices

Plants are rich sources of bioactive compounds which have a beneficial health property beyond the basic nutritional value. Numerous bioactive compounds are present in herbs and spices such as polyphenols, quinines, organosulfur compounds, alkaloids, polypeptides, and their derivatives (Figure 1). The details of major compounds present in specific herbs and spices are given in Table 1. Some of these bioactive compounds may not be essential for daily life as they are not responsible for meeting the basic human nutritional needs. However, they perform essential functions such as to prevent and ameliorate chronic diseases, influence the physiological, immunological, and cellular activities, and to act as enzyme inducer and inhibitor (Liu 2013; Opara *et al*. 2014). Several studies have been carried out to investigate the potential health benefits of bioactive compounds present in herbs and spices such as anti-inflammatory, antioxidant, antimicrobial, chemopreventive, antimutagenic activities, etc. (Guldiken *et al*. 2018, Opara *et al*. 2014; Sachan *et al*. 2018).

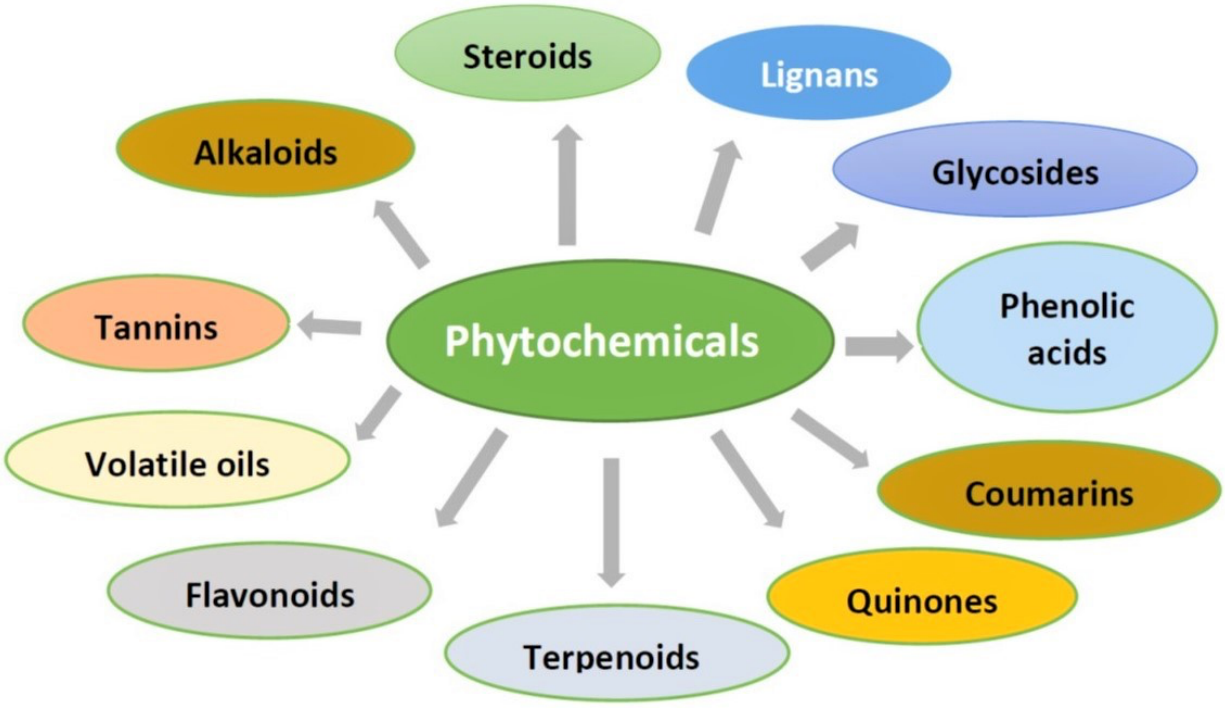

Figure 1. Some major classes of chemical constituents present in herbs and spices

Polyphenols are the secondary metabolite compounds present in plants with diverse structure. These compounds are classified based on the number of phenol rings, one or more aromatic rings attached with hydroxyl groups in their structure. Among the several classes of dietary polyphenols the phenolic acids, flavonoids, tannins, stilbenes, lignans and coumarins (Khan *et al* 2019) are the major group of polyphenols found in plants. A large number of polyphenols is present in plant derived food including herbs and spices, and the content is high in dried forms then in fresh forms. Polyphenols are known for their various pharmacological properties including antioxidant property. Furthermore, they have anti-inflammatory, anticancer, and neuro-protective activities (Adhikari-Devkota *et al* 2019, Khan *et al* 2019, Opara *et al* 2014).

Table 1. Detailed information about traditional uses, major bioactive compounds and pharmacological activities of herbs and spices used in Nepal.

Scientific Name (Family)	**English Name (Nepali name)**	**Traditional uses as spice / medicine**[a]	**Major compounds**	**Pharmacological activities**	**References**
Acmella oleracea (L.) R.K. Jansen (Asteraceae)	Paracress (Gorashpaan)	Flower head for seasoning/ Remedy for toothache and fever.	Spilanthol, triterpenoids, phytosterols, limonene, β-caryophyllene, etc.	Local anesthetic, antipyretic, anti-inflammatory, analgesic, antifungal, diuretic, vasorelaxant, antioxidant, aphrodisiac, antinociceptive, immunomodulatory, etc.	(Dubey *et al.* 2013)
Acorus calamus L. (Acoraceae)	Sweet flag (Bojo)	Leaves, stems, and rhizomes for flavor and aroma / Remedy for digestive disorder, bronchitis, sinusitis, flatulence, dyspepsia and anorexia.	Beta-Asarone, Fatty acids, sugar, acorenone, etc.	Antimicrobial, antioxidant, insecticidal activities, anticonvulsant, neuroprotective and hypolipidemic properties, etc.	(Ramachandran *et al*. 2010; Yende *et al.* 2008)
Allium hypsistum Stearn (Amaryllidaceae)	Jimbu (Jimbhu)	Dried leaves for flavoring and seasoning / Used to treat cough and cold, sore throat, stomach disorder, to cure flues and high-altitude sickness.	1,2 Bis (methylthio) ethene, 2,4 dimethyl thiophene, dimethyl disulfide and dimethyl trisulfide, phenolic compounds, floavonoids, etc.	Antioxidant	(Kattel & Maga 1995, Poudel and Joshi 2016)
Allium sativum L. (Amaryllidaceae)	Garlic (Lasun)	Leaf and clove for seasoning and flavoring/ Remedy for fevers, colic, flatulence, diabetes, rheumatism, intestinal worms, dysentery, liver disorders, high blood pressure and bronchitis	Allicin, alliin, ajoene, diallyl sulfide, diallyl disulfide, diallyl trisulfide, *S*-allyl-cysteine, etc.	Antioxidant, anti-inflammatory, antibacterial, antifungal, immunomodulatory, cardioprotective, anticancer, hepatoprotective, antidiabetic, etc.	(Batiha, 2020a)
Allium cepa L. (Amaryllidaceae)	Onion (Pyaj)	Leaf and bulb for seasoning and flavoring, as vegetable/ Remedy for bruises, colic, colds, fever, earache, bronchitis, intestinal parasites, hypertension, jaundice, sores, and impotence.	Flavonoids, organosulfur, phytosterols, saponins, etc.	Antioxidant, antimicrobial, antidiabetic properties, beneficial against hyperlipidaemia and hypertension, etc.	(Marrelli *et al.* 2019)
Aloe vera (L.) Burm. f. (Asphodelaceae)	Aloe (Ghiu kumari)	Gel from leaves is consumed in the form of juice / Remedy for digestive issues, heart burn and irritable bowel syndrome, wound, used for skin care.	Chromone, anthraquinone, flavonoids,phenylpropanoids, coumarins, phytosterols, naphthalene analogs, lipids, vitamins, etc.	Burn and wound healing property, moisturizing and antiaging effect, immune system restoration, anti-inflammatory, antioxidant, immunomodulatory, antidiabetic, antimicrobial activities, etc.	(Sánchez *et al.* 2020)

Amomum subulatum Roxb. (Zingiberaceae)	Black cardamom (Alichi)	Dried seed for flavor/ Used to relieve discomfort and to treat nausea, vomiting, and bad breath.	1,8-Cineole, □-pinene □-pinene, □-terpineol, etc.	Analgesic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, hypolipidaemic activities, etc.	(Gautam *et al.* 2016, Satyal *et al.* 2012)
Astilbe rivularis Buch.-Ham. ex D. Don (Saxifragaceae)	Goat's beard (Bhudo Okhati)	Flower for aroma/ Used to treat fever, stomachache, diarrhea, gonorrhea, and internal bleeding.	Bergenin, tannins, flavonoids, coumarins, steroids, etc.	Antimicrobial, anti-peptic ulcer, antioxidant, anti-inflammatory, activities, antitussive property, analgesic, antiarrhythmic, hepatoprotective, hypolipidemic and antipyretic activities, etc.	(Hori *et al.* 2018, Devkota 2020))
Brassica napus L. (Brassicaceae)	Rapeseed (Kalo sarsyun)	Dried seed and oil for seasoning/ Seed oil is used to treat common cold, painful joints and muscles, improve appetite.	Glucosinolates, isothiocyanates, flavonoids, volatile compounds, etc.	Analgesic, antimicrobial, antitumor, antihypertensive, antidiabetic, antioxidant, anti-inflammatory, hepatoprotective, nephroprotective, etc.	(Rahman *et al.* 2018)
Bunium persicum (Boiss.) B. Fedtsch (Apiaceae)	Black cumin (Kalo jeera)	Dried seed for flavor/ Used to treat urinary, digestive disorder, inflammation, obesity, and increase breast milk.	Caryophyllene, □-terpene, cuminyl acetate, cuminaldehyde, gamma-terpene-7-al, trans-3-caren-2-ol, acetic-acid, methatriene, p-cymene, cuminyl acetate, limonene, etc.	Antibacterial, antifungal, anticonvulsant effects, antihistaminic, antinociceptive, anti-inflammatory, , antioxidant, etc.	(Hassanzadaza *et al.* 2018; Shah *et al.* 2019)
Cannabis sativa L. (Cannabaceae)	Hemp seed (Bhang)	Dried seed for seasoning/ Beneficial to treat nervous disorders and constipation.	Cannabidiol, , terpenes, phenolic compounds, etc.	Protective effect against cardiovascular diseases, metabolic syndrome, skin disorders, and neurologic disorders, etc.	(Leonard *et al.* 2020)
Capsicum annuum L. (Solanaceae)	Chilli (Khursani)	Fresh and dried fruit as colorant, flavoring/ Used as appetizer, weight loss, for inflammation, to cure numbness.	Capsaicinoids, carotenoids, flavonoids, steroid, saponins, etc.	Antioxidant, cancer chemopreventive, antidiabetic, gastroprotective, and antimicrobial activities, pain relief, treatment of metabolic syndrome, etc.	(Salehi *et al.* 2018)
Carcum bulbocastanum (L.) Koch	Black caraway seed (Bhote Jeera)	Leaves and seed for seasoning and flavor/ Used to treat cough, gas, constipation, allergies.	Dillapiole, germacrene-beta, nothoapiole, □-selinene, etc.	Antioxidant, antimicrobial, etc.	(Kapoor *et al.* 2010, Nariman *et al.* 2009)
Centella asiatica (L.) Urb. (Apiaceae)	Asiatic pennywort (Ghodtapre)	Leaves as vegetable salad/ Remedy for urinary tract	Triterpenoid saponins, asiaticoside, brahmoside, brahmic acid, etc.	Wound healing, sedative, anxiolytic antidepressant, antiepileptic, antioxidant,	(Brinkhaus *et al.* 2000)

		infections, fever, improve appetite.		antinociceptive, anti-inflammatory, etc.	
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm. (Lauraceae)	Bay leaf (Tejpat)	Fresh or dried leaf for aroma and flavor/ Used for the treatment of skin rashes, bad mouth odor, earaches, and rheumatism.	Saponins, phytosterols, fatty acids, monoterpene, sesquiterpene, geraniol, linolol, bornyl acetate, caryophylene oxide, p-coumaric acid, vanillic acid, etc.	Antidiarrheic, antitumor, anti-inflammatory, antiarthritic, antitumor, antioxidant, Cancer chemopreventive, and gastroprotective effect, antimicrobial, antipyretic, anxiolytic, etc.	(Rao & Gan 2014, Sharma & Rao 2014)
Cinnamomum verum J.Presl (Lauraceae)	Cinnamon (Dalchini)	Dried bark for flavor/ Used in treating sore throats, cough, indigestion, abdominal cramps, intestinal spasms, nausea, flatulence, and diarrhea.	Cinnamaldehyde, eugenol, linalool, phenolic acids, tannins, etc.	Anti-inflammatory, antimicrobial, antioxidant, antitumor, cardiovascular, cholesterol- and lipid-lowering properties, and immunomodulatory effects, hypoglycemic properties, etc.	(Gruenwald *et al.* 2010, Rao & Gan 2014)
Coriandrum sativum L. (Apiaceae)	Coriander (Dhaniya)	Fresh leaves and dried seeds for flavoring and seasoning / Remedy for sore throat, allergies, digestion problems, hay fever.	Flavonoids, ferulic acid, salicylic acid, gallic acid, coumarins, tartaric acid, maleic acid, arbutin, etc.	Antioxidant, diuretic, antidiabetic, sedative, antimicrobial, anti-convulsant, hypnotic, anthelmintic, antimutagenic, etc.	(Nadeem *et al.* 2013)
Crocus sativus L. (Iridaceae)	Saffron (Keshar)	Dried stigma for seasoning and coloring/ Remedy for skin disease, asthma, cold and cough.	Crocin, kaemferol, safranal, etc.	Antioxidant, anti-inflammatory, antimicrobial antidiabetic, aphrodisiac, anxiolytic, antitumor activities, hepatoprotective, nephrotoxicity, neuroprotective, immunomodulatory, and anticonvulsant, etc.	(Rahmani *et al.* 2014)
Cuminum cyminum L. (Apiaceae)	Cummin (Jeera)	Whole seeds and ground powder as perfumery and seasoning / remedy for indigestion, jaundice, diarrhea, cold and flatulence.	Alkaloid, coumarin, anthraquinone, flavonoid, glycoside, protein, resin, saponin, tannin, steroid, etc.	Antimicrobial, anti-inflammatory, analgesic, antioxidant, hypotensive, anti-osteoporotic, tyrosinase inhibitory effects, etc.	(Al-Snafi 2016; Gangadharappa *et al.* 2017)
Curcuma aromatica Salisb. (Zingiberaceae)	Wild turmeric (Ban haledo)	Rhizome for aroma / Used as carminative, appetizer and tonic. Used for the treatment of cough, bronchitis and fever.	Sesquiterpenoids, e.g., isozedoarondiol, methylzedoarondiol, neocurdione, germacrone, curdione, zedoarondiol, etc.	Antianalgesic, antimicrobial, anti-inflammatory, anticancer, etc.	(Devkota *et al.* 2021, Umar *et al.* 2020)
Curcuma caesia Roxb. (Zingiberaceae)	Black turmeric	Rhizome for aroma/ Remedy for cough, cold, pneumonia, wounds, tooth ache, vomiting,	ar-Turmerone, (*Z*)-ocimene, ar-curcumene, cineole,	Antifungal, smooth muscle relaxant and anti- asthmatic	(Baghel *et al.* 2013, Das *et al.* 2013)

	(Kalo haledo)	allergies, leucoderma, asthma and menstrual diorders.	elemene, borneol, bornyl acetate, curcumene, etc.	activities, analgesic, anthelmintic, antioxidant, etc.	
Curcuma longa L. (Zingiberaceae)	Tumeric (Beshar)	Rhizome for flavor and color / Remedy for cough, diabetes, wounds, hepatic disorders, rheumatism, and sinusitis.	Curcumin, demethoxycurcumin, bisdemethoxycurcumin, zingiberene, curcumenol, curcumol, eugenol, tetrahydrocurcumin, triethylcurcumin, turmerin, turmerones, turmeronols, etc.	Anti-inflammatory, antioxidant, anticoagulant, antidiabetic, antimicrobial, antiulcer, wound healing, anticancer, antiarthritis activities, etc.	(Eigner & Scholz 1999, Devkota *et al.* 2021, Li *et al.* 2020)
Drymaria cordata subsp. *diandra* (Blume) J.A. Duke (Caryophyllaceae)	Chickweed (Abijalo)	Leaves as vegetable salad/ Remedy for asthma, blood disorders, conjunctivitis, constipation, inflammation, dyspepsia, skin ailment.	Alkaloids, saponins, coumarins, steroids, terpenoids, etc.	Analgesic, antinociceptive, anti-inflammatory, antibacterial antipyretic, antitussive activities, etc.	(Kashyap *et al.* 2014)
Elettaria cardamomum L. Maton (Zingiberaceae)	True cardamom (Sukmel)	Dried seed for flavor/ Used to treat nausea, indigestin, cold cough and bad breath .	α-Terpinyl acetate, 1,8-cineole, etc.	Diuretic, stimulant, stomachic, tonic, and antispasmodic, antimicrobial, anti-inflammatory, etc.	(Ashokkumar *et al.* 2020)
Ferula assa-foetida L. (Apiaceae)	Asafetida (Hing)	Rhizome for flavor / Used to reduce bloating, remedy for indigestion, headache and to cure insects bite.	Gum, resin, coumarins, ferulic acid, and volatile compounds, etc.	Antidiabetic, antioxidant, antiulcer, hepatoprotective, antiviral, antifungal, anthelmintic, antispasmodic, hypotensive, etc.	(Eigner & Scholz 1999, Mahendra *et al.* 2012)
Foeniculum vulgare Mill. (Apiaceae)	Fennel (Saunf)	Dried seed as flavor and aroma / Used to treat bloating, loss of appetite, and colic in infants.	Saponins, flavonoids, cardiac glycosides, sterols, triterpenes, coumarins, volatile oils, etc.	Antimicrobial, antifungal, antioxidant, antithrombotic, anti-inflammatory, hepatoprotective, antitumor, activities, etc.	(Rather *et al.* 2016)
Glycyrrhiza glabra L. (Fabaceae)	Licorice (Jethi madhu)	Stem and rhizome/ Remedy for heartburn, acid reflux, hot flashes, coughs, sore throat, and bacterial and viral infections.	Glycyrrhizin, glycyrrhetic acid, isoliquiritin, isoflavones, etc.	Anticoagulant, expectorant, antidemulcent, antiulcer, anticancer, anti-inflammatory, antidiabetic, antiviral, antioxidant, hepatoprotective, immunomodulatory, etc.	(Batiha *et al.* 2020b)
Illicium verum Hook. f. (Schisandraceae)	Star anise (Chakraphul)	Dried fruit foe flavor / Beneficial for rheumatism, digestion, cough, food poisoning and sore throat.	Prenylated flavonoids, lignans, sesquiterpenes, etc.	Anti-inflammatory, antioxidant, antimicrobial, antifungal, anthelmintic, insecticidal, expectorant, sedative, gastroprotective and antinociceptive, etc.	(Patra *et al.* 2020, Wang *et al.* 2011)

Lindera neesiana (Wall. ex Nees) Kurz (Lauraceae)	- (Siltimur)	The fruits are aromatic and are used as a spice/ Used in traditional medicines to treat diarrhea, tooth pain, headache, and gastric disorders.	*Z*-citral, *E*-citral, eucalyptol, citronellal, *α*-pinene, *β*-pinene, etc.	Antibactrial, antifungal, neuroprotective, antineuroinflammatory, etc.	(Adhikari-Devkota *et al.* 2019a, Comai *et al.* 2010, Subedi et al. 2016)
Linum usitatissimum L. (Linaceae)	Flax (Aalas)	Dried seed for seasoning/ Used to treat chronic constipation and symptoms of irritable colon.	Linolenic acid, linoleic acid, lignans, cyclic peptides, alkaloids, cyanogenic glycosides, cadmium, etc.	Antifungal, antioxidant, antihypertensive, cholesterol lowering, antidiabetic, antithrombic, antiobesity activities, etc.	(Goyal *et al.* 2014, Tavarini *et al.* 2019)
Mangifera indica L. (Anacardiaceae)	Mango powder (Amchur)	Powder from dried unripe green mango for flavor / Used to improve digestion, aids in weight loss.	Tannins, alkaloids, saponins, cardiac glycosides, steroids, flavonoids, terpenoids, etc.	Antimicrobial, antitumor, antidiabetic, analgesic, and anti-inflammatory activities, antipyretic, antiallergic hepatoprotective, etc.	(Gupta *et al.* 2010, Kabir *et al.* 2017)
Mentha arvensis L. (Lamiaceae)	Wild mint (Pudina, Babari)	Leaves for seasoning / beneficial for headaches, digestive disorders diarrhea and menstrual cramps.	Menthol, menthone, limonene, methyl acetate, piperitone, □-caryophyllene, □-pinene, tannins, flavonoids, etc.	Antibacterial, antioxidant, antifertility, anti- allegoric, anti-inflammatory, radioprotective activities, etc.	(Thawkar *et al.* 2016)
Mentha spicata L. (Lamiaceae)	Spearmint (Pudina)	Fresh leaves for flavor and pickele / Beneficial for stomachache, alleviating indigestion, gas, and cramps.	Flavonoids, phenolics, lignans, stilbenes, essential oils, etc.	Antioxidant, antimicrobial, anti-viral, anti-inflammatory, biopesticidal, larvicidal, anticancer, radioprotective effect, genotoxicity, and antidiabetic activities, etc.	(Mahendran and Rahman 2020)
Murraya koenigii (L.) Spreng (Rutaceae).	Curry leaves (Mitho neem)	Fresh leaves for seasoning/ Used for weight loss, aid digestion, reduce inflammation.	Koenimbine, koenine, mahanimbine, murrayazolidine, murrayazoline, murrayacine, girinimbine, mukoeic acid, etc.	Antioxidant, antimicrobial, anthelmintic, analgesic, anti-inflammatory, antidiarrhea neuroprotective, hepatoprotective, antitumor, etc.	(Balakrishnan *et al.* 2020, Gahlawat *et al.* 2014)
Myristica fragrans Houtt. (Myristicaceae)	Nutmeg (Jaiphal)	Dried seed for flavor/ Used for the treatments of asthma, heart disorder and bad breath.	Myristicin, elemicin, safrole, terpenes, myristic acid, etc.	Antimicrobial, antidepressant, antidiabetic, aphrodisiac, cytotoxicity, antioxidant, hepatoprotective, etc.	(Ha *et al.* 2020)
Nigella sativa L. (Rananculaceae)	Black cumin (Mungrelo)	Dried seed for seasoning / use of cough, headache, fever, jaundice, eyesores, nasal ulcer.	Thymoquinone, thymohydroquinone, dithymoquinone, p-cymene, carvacrol, 4-terpineol, t-anethol, sesquiterpene longifolene α-pinene, thymol, etc.	Antidiabetic, analgesic, anticancer, antimicrobial, anti-inflammatory, antioxidant, spasmolytic, gastro-protective, etc.	(Ahmad *et al.* 2013)

Ocimum tenuiflorum L. (Lamiaceae)	Holi Basil (Tulasi)	Fresh and dried leaves and stem for flavor/ Beneficial for common cold, fever, stress, and anxiety.	Rosmarinic acid, Oleanolic acid, ursolic acid, flavonoids, eugenol, carvacrol, linalool, *β*-caryophyllene, etc.	Antidiabetic, wound healing, antioxidant, hypolipidemic, gantimicrobial, immunomodulatory, antinociceptive, anthelmintic, anti-inflammatory and anticancer, etc.	(Pattanayak *et al.* 2010)
Phyllanthus emblica L. (Phyllanthaceae)	Gooseberry (Amala)	Fresh and dry fruits for flavor / Used for the treatment of diarrhea, nausea and for skin and hair disorders.	Ascorbic acid, fixed oils, phosphatides, essential oils, tannins, minerals, vitamins, aminoacids, fatty acids, glycosides, etc.	Antimicrobial, anti-inflammatory, antidiabetic, antidiarrheal, hypo-lipidemic, hepatoprotective, anticancer, cardioprotective, neuroprotective antitussive, antiproliferative, immunomodulatory, analgesic, antipyretic, etc.	(Gaire and Subedi 2014)
Piper longum L. (Piperaceae)	Long pepper (Pipla)	Dried fruit for seasoning / Used to improve appetite and digestion, treat stomachache, heartburn, indigestion, intestinal gas, diarrhea.	Piperine, piperlongumine, diaeudesmin pipermonaline, etc,	Antioxidant, anti-inflammatory, antimicrobial, antiplatelet, antifertility, antihyperlipidemic, antiobesity, hepatoprotective, analgesic, larvicidal, radioprotective, cardioprotective, antidepressant, and antifungal activities, etc.	(Yadav *et al.* 2020)
Piper nigrum L. (Piperaceae)	Black pepper (Marich)	Dried fruit for flavor and aroma/ Remedy for indigestion, bloating, cough and cold, infection.	Piperine, volatile oil, oleoresins, alkaloids, etc.	Antimicrobial, antioxidant, anticancer, neuro-protective, hypoglycemic, anticonvulsant, analgesic, hypolipidemic and anti-inflammatory activities, etc.	(Takooree *et al.* 2019)
Punica granatum L. (Lythraceae)	Pomogranate seed (Anardana)	Dried seed for flavor / Used to improve cognitive health, and to treat hypertension.	Alkaloids, saponins, terpenoids, anthraquinones, tannins, etc.	Anti-inflammatory, anticancer, antidiabetic, antarthritic, wound healing activities, etc.	(Bassiri-Jahromi 2018, Singh *et al.* 2012)
Sesamum indicum L. (Pedaliaceae)	Sesame (Til)	Dried seed for flavoring and seasoning/ Used for skin and hair disorders and in diabetes.	Sesamin, pinoresinol, sesamol, sesamolin, etc.	Antimicrobial, antioxidant, hepatoprotective, anthelmintic, cardioprotective, etc.	(Gupta *et al*. 2010, Kabir *et al.* 2017)
Syzygium aromaticum (L.) Merr. & L.M. Perry	Clove (Lwang)	Dried flower bud for aroma and flavor / Remedy for tooth ache and sore gums, cough and cold, fever, digestive problems, etc.	Eugenol, eugenyl acetate, β-caryophyllene, etc.	Analgesic, antioxidant, anticancer, antiseptic, antidepressant, antispasmodic, anti-inflammatory, antiviral,	(Devkota & Adhikari-Devkota 2020)

				antifungal, and antibacterial, etc.	
Terminalia bellirica (Gaertn.) Roxb. (Combretaceae)	Beleric myrobalan (Barro)	Dries fruit used for respiratory tract infection, cough, and sore throat.	Glucoside, tannins, gallic acid, ethyl gallate, chebulinic acid, etc.	Analgesic, antidiarrhoeal, antihypertensive, antimicrobial, antioxidant, antispasmodic, antipyretic, etc.	(Thawkar *et al.* 2016)
Terminalia chebula (Gaertn.) Roxb. (Combretaceae)	Chebulic myrobalan (Harro)	Dried fruit used for cough, digestive, and urinary problem.	Sapogenins, saponins, anthraquinone derivatives, flavonoids, tannins, etc.	Anticancer, anti-inflammatory, antioxidant, antimicrobial, wound healing, etc.	(Kolla *et al*. 2018, *Nigam et al.* 2020)
Tinospora sinensis (Lour.) Merr. (Menispermaceae)	Heart-leaved moonseed (Gurjo)	Root, stem, and leaves used in the form of juice and powder/ Remedy for fever, digestion, arthritis, boost immunity.	Terpenoids, alkaloids (berberine, palmatine, etc.), glycosides, steroids, phenolics, , etc.	Antioxidant, antimicrobial, antidiabetic, hypolipidemic, anticancer activities, wound healing, immunomodulating activities, etc.	(Sharma BR *et al.* 2019, Sharma P *et al.* 2019)
Trachyspermum ammi (L.) Sprague (Apiaceae)	Carom (Jwano)	Dried seed for flavoring / Beneficial for diarrhea, dyspepsia, flatulence, indigestion, and cholera.	Phenolic compounds, saponins, volatile oil (thymol, γ-terpinene, p-cymene, and α-pinene, β-pinene), etc.	Antifungal, antioxidant, antimicrobial, antinociceptive, antihypertensive, diuretic, antitussive, etc.	(Bairwa *et al.* 2012
Trigonella foenum-graecum L. (Fabaceae)	Fenugreek (Methi)	Fresh leaves and dried seeds as vegetable flavoring, seasoning / Used for increasing breast milk, treating diabetic wounds, skin irritation and lowering, cholesterol.	Trigonelline, isoorientin, orientin, vitexin, isovitexin, etc.	Hypoglycemic, antihypertensive, antioxidant, immunomodulatory wound healing, hepatoprotective, appetizer, etc.	(Wani *et al.* 2018)
Zanthoxylum armatum DC. (Rutaceae)	Timur pepper (Timur)	Dried fruit for flavor and aroma / Remedy for toothache, common cold, cough, and fever.	Amides, oxygenated monoterpenes, *Cis*-9-hexadecenoic, eicosenoic, palmitic acids, tambuletin, etc.	Antimicrobial, antioxidant, anti-inflammatory activities, immunomodulatory, antidiabetic, hepatoprotective, cardiovascular effects, etc.	(Singh *et al.* 2011)
Zingiber officinale Roscoe (Zingiberaceae)	Ginger (Aduwa/Sutho)	Dried and fresh rhizome for flavoring/ Remedy for cough and cold, dyspepsia, flatulence, abdominal discomfort and nausea.	Gingerols, shogaols, terpene, etc.	Antioxidant, anti-inflammatory, antiemetic, antimicrobial, anticancer, antidiabetic activities, neuroprotection, cardiovascular protection, etc.	(Mao *et al.* 2019

[a]Traditional uses are mainly from following references: Baral and Kurmi 2006, Joshi and Joshi 2006, Manandhar 2002, Watanabe et al. 2005, Watanabe et al. 2013 along those provided in references column.

Terpenoids are another class of major phytochemicals present in herbs and spices which are classified into various group based on the number of isoprene units. They are the major constituent of essential oils present in plant and used for their aromatic qualities which are used in traditional medicine. Monoterpenes are a class of terpenoids having two isoprene unit which present in the essential oil extracted from many plants including herbs and spices. Thymol, α-terpineol, limonene, menthol, carvone, eucalyptol, perillaldehyde, borneol, camphor, citral, geraniol, lavandulol, and linalool, etc. are some examples of monoterpenes present in plants. These bioactive molecules exert various medicinal properties like anticancer, antimicrobial, antifungal, antiviral, antihyperglycemic, analgesic, anti-inflammatory, and antiparasitic activities. Carvone in caraway, menthol in peppermint, thymol in thyme, linalool in coriander, citral in lemongrass, β-caryophyllene in clove, α-zingiberene in ginger, capsaicin in chili pepper is some examples of terpenoids present in herbs and spices (Ludwiczuk *et al* 2017).

Saponins are steroid and triterpenoids glycosides present in plants which possess a surface active or detergent property having diverse biological activities (Hussain *et al* 2019, Marahatha *et al* 2021). Plant families such as Agavaceae, Amaryllidaceae, Asparagaceae, Bromeliaceae, Dioscoreaceae, Liliaceae, Palmae and Scrophulariaceae are rich in saponins (Hussain *et al* 2019). These compounds exert various pharmacological activities such as anti-inflammatory, anti-cancer, antidiabetic, hepatoprotective, immunomodulatory activities (Ashour *et al* 2019).

Alkaloids are another group of phytochemicals that contain nitrogen atom in ring structure. Alkaloids are divided into several groups: pyrollidine, pyrrolizidine, pyridine, quinoline, isoquinoline, imidazole, etc. Several alkaloids show significant medicinal activities, such as morphine exhibit analgesic activities, ephedrine is good for asthma (Lu *et al* 2012).

Regarding herbs and spices commonly used in Nepal, only a few studies have been performed to isolated and identify active chemical constituents or their qualification. Devkota *et al* (2010) studied the geographical variation in major chemical constituents of *Centella asiatica* in Nepal. Similarly, a preliminary HPLC profile of commonly available herbs and spices was established (Devkota *et al* 2017). Thapa *et al* (2009) analyzed the content of capsaicin in various varieties of chilli pepper in Nepal. Poudel *et al* (2019) analyzed the contents of curcumin in turmeric collected from various localities in Nepal. Few studies have also performed on the constituents of essential oils obtained from herbs and spices in Nepal (Satyal *et al* 2012, Satyal *et al* 2013). For most of the herbs and spices, major constituents listed in Table 1 are not from the studies conducted on the samples collected from Nepal. As the chemical constituents in plants are reported to vary according to the environmental and genetic factors, cultivation condition, collection time and processing, detailed studies should be carried out to identify and quantify the major chemical constituents of herbs and spices available in Nepali market.

Pharmacological activities of herbs and spices

Most of the herbs and spices used in Nepalese kitchen have been attributed with medicinal properties. Many of the herbs and spices uses in culinary purpose possess different pharmacological activities such as antimicrobial, anti-inflammatory, antioxidant, antidiabetic, antihyperlipidemic, hepatoprotective, antipyretic, digestive, etc. Some of these activities are summarized in Figure 2.

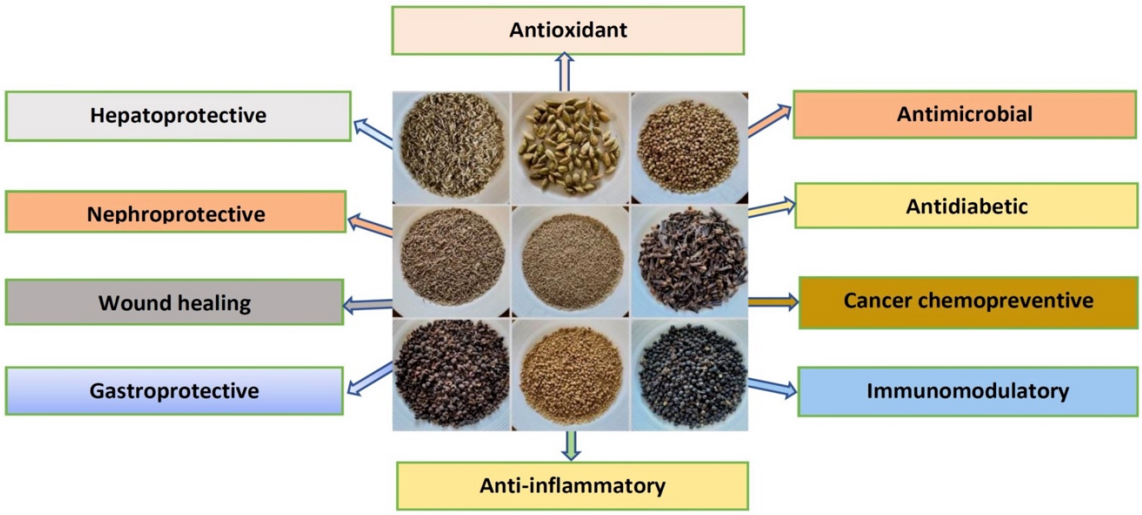

Figure 2. Representation of various pharmacological activities of herbs and spices

Antioxidant activities

Antioxidants are the compound that inhibit free radicals and prevent from the oxidative damage of a molecule. Oxidation can produce free radical which can damage the cells of organism leading various chronic diseases such as cancer, diabetes, cardiovascular and neurological diseases, etc. Oxidative stress can be induced by many negative factors like unhealthy diet, radiations, adverse environmental condition, and psycho-emotional stress (Devkota *et al* 2006, Serafini & Peluso 2016). Phytochemicals like flavonoids, terpenes, lignans, phenolic acids, etc. act as antioxidant which protect against the cell damage caused by free radicals (Yashin *et al* 2017). Different herbs and spices are the rich source of these phytochemicals which have powerful antioxidant activity. Curcumin from turmeric, capsaicin from chili pepper and gingerol from ginger, eugenol from clove is some examples of bioactive compound with strong antioxidant activities (Guldiken *et al* 2018). Spices like clove, cumin coriander, nutmeg, pepper, cardamom etc. have a major antioxidant activity with their high content in phenolic and flavonoids compound (Słowianek *et al* 2016).

Anti-inflammatory activities

Anti-inflammatory agents either reduce the synthesis and activity of inflammatory mediators or increase synthesis and activity of anti-inflammatory mediators. Inflammation is induced as an immune response to cellular damage or pathogenic infection. Inflammation can cause the disorders like asthma, arthritis, rheumatism and other many chronic diseases (Mueller *et al* 2010). Studies have suggested that numerous herbs and spices contain bioactive compounds that have anti-inflammatory properties. Several studies have demonstrated the bioactive compounds present in herbs and spices with anti-inflammatory properties in vivo and in vitro models (Mueller *et al* 2010). Major group of compounds that possess anti-inflammatory activities with antioxidant effects are phenolic acid, terpenes, and flavonoids (Liu 2013). It has been reported that culinary herbs and spices like clove, basil, cinnamon, cumin, nutmeg, bay leaf, ginger, turmeric, star anise and carom elicited an anti- inflammatory effect by inhibiting the pro-inflammatory enzymes (Jungbauer *&* Medjakovic 2012).

Antimicrobial activities

Multiple illnesses can be caused by the microbial infections. Antimicrobials are the compounds that either kill or inhibit the growth of broad-spectrum bacteria, virus, or fungi. Studies has shown that phytochemicals exert antimicrobial activity via mechanism of action like damage of cell membrane, inhibition of enzyme and toxin activity, suppression of virulence factor or by formation of bacterial biofilm (Guldiken *et al* 2018, Ullah *et al* 2020). Several herbs and spices used in Nepali kitchen exhibit highly potent bioactive compounds such as flavonoids, alkaloids, tannins, glycosides, saponins which attributed as a defense mechanism against different microorganisms, insects and herbivores. Allicin present in garlic, cinnamaldehyde present in cinnamon, allyl isothiocyanate present in mustard are some example of antimicrobial components presents (Naser Al-Wabel *et al* 2013). A wide variety of herbs and spices such as clove, cinnamon, mustard, garlic, ginger, mint, cumin, turmeric, pepper and coriander possess an antimicrobial activity against bacteria like *Bacillus subtilis*, and *Pseudomonas florescens* and fungi like *Aspergillus flavus* and *Staphylococcus aureus* (Liu *et al* 2017, Skrinjar *et al* 2009).

Antidiabetic activities

Diabetes is a common metabolic disorder around the world. It is the condition where pancreatic cells become either unable to secrete insulin or there is insulin resistance leading to defective utilization of glucose. Most of the herbs and spices contain phytochemicals like glycosides, alkaloids steroid, carotenoids, flavonoids, tannins, polyphenols, etc., which show antidiabetic activities by various mechanisms e.g. causing an increase in insulin output by restoring the function of pancreatic tissue, or by hindering the absorption of glucose in intestine (Jugran *et al* 2020, Patel *et al* 2012).The major potentially beneficial effects seen in diabetics reported in the literature were reduction in blood glucose, reduction in lipid levels, and regulation of insulin secretion (Pereira *et al* 2019). The kitchen herbs and spices that have the possible benefits in the treatment of diabetes are pepper, turmeric, saffron, lemon, ginger, garlic, fenugreek, flaxseed and caraway (Ingle 2013).

Cancer chemopreventive and anticancer activities

Cancer is the condition due to unwanted proliferation of abnormal cells in the body. Worldwide, cancer is one of the leading causes of death. Common kitchen herbs and spices play a vital role in the treatment and prevention of cancer. In vitro and preclinical studies using animal models have indicated that the herbs, spices, and their bioactive components show potent cancer chemopreventive and anticancer activities (Kaefer and Milner 2008). Studies have reported that bioactive compound like curcuminoids, flavonoids and other polyophenols, volatiles oil, and organosulfur compounds act through various mechanisms in cancer (Cragg & Pezzuto 2016, Dehelean *et al* 2021, Haque *et al* 2021, Zheng *et al* 2016).

Effects on cardiovascular diseases

Cardiovascular diseases are the problems associated with heart and blood vessels. Cardiomyopathy, hypertension, myocardial ischemia, arrhythmia is some examples of cardiovascular diseases. Studies has found that consumption of herbs and spices rich in bioactive compounds such as flavonoids, diosgenin, sulforaphane, tocotrienols and carotenoids are proven to lower the risk of cardiovascular diseases and aids in preventing the diseases (Gervasi et al 2021, Li et al 2020,). Studies have suggested that high content of phenolic and sulfur containing compound i.e., allicin, alliin, found in garlic are associated with anti- hypertensive, anti-thrombotic and anti-glycemic effects (Batiha *et al.* 2020a).

Immunomodulatory effects

The immune system is a complex network of cells and proteins which act as a defense mechanism against any infections, and it plays a vital role to protect human body from illness. A well function and strong immune system is the foundation of healthy body (Cherng *et al*. 2008). Several herbs and spices used for culinary purpose have various bioactive compounds having potential immunomodulatory activities. Extracts of different herbs and spices and their compounds such as polyphenols, alkaloids, terpenoids, phytosteroids etc. have been widely studied for their immunomodulatory activities (Catanzaro *et al* 2018, Thangadurai *et al* 2018). Several studies have shown that these compounds act as immunomodulator by increasing total antibody production, total WBC count, suppressing cytokine production, inhibiting PHA-stimulated proliferation of peripheral blood mononuclear cells IL-2 and TNF-α, enhancing the production of IgG1 and IgG2b, etc. (Venkatalakshmi *et al* 2013).

Although, the pharmacological activities of different herbs and spices are well studied using in vivo and in vitro experiments, the number of clinical studies is very low. Similar to chemical constituents, the pharmacological activities listed in Table 1 are not specific to the herbs and spices in Nepali market. Detailed studies should be carried out to evaluate the pharmacological activities of these herbs and spices and to elucidate the mechanism of action of these extracts/compounds.

Conclusion

Globally, the use of herbs and spices as natural ingredients to enhance the taste of food with flavor, color, aroma and as preservatives has been increasing in recent years. These are not just used for exquisite flavors and food enhancer but also for the medicinal and nutritional value. In this paper, we documented 50 most commonly used herbs and spices in Nepali kitchen. These herbs and spices are used as flavoring agents in many recipes and also for their potential health beneficial activities. In normal condition, these herbs and spices are used in food recipes mixing with many other food ingredients. However, for the treatment of diseases/symptoms, these herbs and spices are used as single agent or by mixing with other herbs. The amount/dose of these herbs and spices vary based on their uses as food ingredient or medicinal purposes. Nepal having ethnic, cultural and linguistic diversity, it is necessary to document these traditional uses in a form of easily accessible database having all information related to local names, cultural values and their uses in diverse ethnic recipes. Preparation of such database will not only help in preservation of traditional knowledge but also in the development of evidence-based medicines.

Many herbs and spices covered in this paper are also common in other South Asian countries and they are also gaining popularity in other parts of the world. Studies related to chemical constituents and pharmacological activities covered in this paper are not specific to herbs and spices available in Nepali market. Detailed research should be carried out to identify major chemical constituents and to develop chemical profiles of herbs and spices available in Nepali market. On the other hand, most of the pharmacological activities mentioned in this paper were based on in vitro and animal studies. Thus, their therapeutic efficacy should be established on the basis of detailed clinical studies. Similarly, studies related to their safety, possible toxicities and interaction with other therapeutic agents should also be carried out.

In recent years, there is growing demand for the phytochemical-based nutraceuticals, functional foods, food supplements and cosmetic formulations. Herbs and spices commonly used in Nepal have high potential to be developed into these formulations, which needs detailed study in future which may open up the new opportunities for herbs-based enterprises. Market research with focus on the overall production, domestic demand and export/import of these herbs and spices is necessary in future. Research collaboration between multidisciplinary fields and academia-private partnership can help not only in healthcare sector but also in the strengthening the local economy.

Declarations

List of abbreviations: Not applicable.

Ethics approval and consent to participate: Not applicable.

Consent for publication: This paper does not include any individual person´s data and further permission for publication is not required.

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