


Exploration of the diversity and associated health benefits of traditional pickles from the Himalayan and adjacent hilly regions of Indian subcontinent

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Abstract The Himalayas have provided shelter to the various communities for thousands of years and have remained the cradle for the origin of diverse cultures and traditions. The Himalayan belt is rich in biodiversity and have ushered mankind with numerous gifts for survival and existence. The art of pickling is believed to have developed independently among the different communities of this region. In this region, the main meal is supplemented with pickles or *achar* that not only adds flavour, but also enhances the value of the meal and often comes with inherent health benefits. The prime objective of this article was to enlist the diverse pickles that are being prepared and consumed by the different tribes and communities, and at the same time analyse the science behind pickle preparation and health benefits and concerns associated with pickles. We have enlisted about hundred monotypic pickles, that are prepared from single fruit or vegetable; but sometimes fungi such as *Agaricus* and ferns like *Diplazium* and *Pteridium* have also been used. Also, fish and meat pickles are common mostly in the Eastern Himalayan region. Traditional pickles constitute the medicinal values of the ingredients and other beneficial properties conferred by the associated microorganisms.

Keywords Preservation · Pickle · *Achar* · Himalaya · Chutney

Introduction

Food preservation techniques from times immemorial have contributed in maintaining the quality and characteristics of food items for an extended period of time. Ancient civilizations used to store perishable food items in air tight containers such as clay jars to keep the food away from air and moisture, thus slowing the spoiling process. Drying fruits, vegetables and meats was one of the major techniques practised by the ancient people (Ratti 2001). Salting the fruits and vegetables was also known, which was often practised during the middle ages for preservation. The major concern of food preservation was concentrated to overcome the huge burden on seasonal crop production and unavailability of certain food crops throughout the world (Monika et al. 2016). At present, food preservation techniques depend on drying, salting, sugaring, pickling, canning, refrigeration and smoking (Click and Ridberg 2010).

Food preservation in the form of pickle has been one of the strategies for lengthening the shelf life of fruits and vegetables. The word pickle has originated from the Dutch word ‘pekel’ that was used to refer to a solution of brine often spiced, for preserving and flavouring food (Bowen and Ralph 2003). The term ‘pickle’ can be associated with processed fruits and vegetables in salt and spice mixture that have an extended shelf life, often with restored or enhanced beneficial properties of the entities involved. The art of making pickles is known as ‘pickling’ and it has been an integral part of all the communities and cultures across the globe for millions of years. The principle objective of pickling is to delay the spoilage and contamination of food

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stuff by natural microflora. Moreover, the addition of some ingredients like spices in the pickling process enhanced the flavour and nutritive value of the end product. Pickling involves preserving the food stuffs under low pH condition using brine, vinegar or other acid (Krishnan et al. 2004). Due to low pH and high acid contents, food items can be successfully biopreserved for more than 2 years without refrigeration (Tamang 1998).

The exact origin of pickling however is uncertain, but according to the archaeologists and anthropologists it dates back to 2400 B.C., when the ancient Mesopotamians were believed to know the art of preservation of fruits and vegetables (Bowen and Ralph 2003). The process of pickling found its true relevance around 2030 B.C., when the cucumbers brought from far fledged locales of Indian sub-continent were preserved in the Tigris valley and thus initiated a new tradition (Bowen and Ralph 2003). In the Indian sub-continent, especially in the Himalayan and adjacent belts, pickle is popularly known as '*achar*' and generally no meal is complete without a smidgen of pickle. Pickles are often consumed along with main course dishes and act as good appetizer and digestive agent (Monika et al. 2016). Fish and meat are also used for storage in the form of pickle (Mahalingam 2015). Moreover, the pickles instantly add some extra taste, flavour and texture to the usual fruits and vegetables. Economically, pickling successfully minimizes the price fluctuation between peak harvesting period and off season, and also reduces the losses due to post-harvest spoilage of fruits and vegetables (Sultana et al. 2014).

This review aims to explore the different forms of pickles that are prepared and consumed by the various communities of the Himalayan and adjacent hilly regions of the Indian sub-continent, mostly because the population in this area is rural, often geographically isolated and also distinct in their food habit, culture and tradition. Moreover, our aim was to introspect the cultural impression of different communities on pickle production and the associated health benefits imparted to their day to day life.

Pickles: the cultural footprints

In the Himalayan and adjacent belts, the lifestyle of people is very simple and so is reflected by their simplicity in food habit. The staple food of an average individual in this region is basically *bhat/chawal*, *dal* and *tarkari* (rice, pulses and vegetables); and often *bhat* is replaced by *roti/chapati* (Banskota 2012; Tamang and Thapa 2014). Occasionally, the main meal is supplemented with fish or meat items; but pickles or *achar* are an inseparable addition to an average meal which adds flavour and value to the meal served.

The exact origin and development of pickles in this region is untraceable due to the lack of age old manuscripts. Though it could be assumed that owing to the rough terrains and practically unapproachable locales common to the entire region may have been the common driving force behind the development of the art of pickling independently among the communities residing here for millions of years. Pickles have been an indispensable part of the social rituals of different ethnic communities. In *Bhujel* community of Sikkim, the wedding proposal from the boy's side is sent along with some traditional dishes like *selroti*, *raksi* and *achar*. If the gifts are accepted by girl's side, the marriage is happily settled, but if the gifts are left untouched, the proposal is deemed to be rejected (Bisht and Bankoti 2004). Similarly, in *Durra* community of Nepal, groom's party (*Janti*) is welcomed by feeding them *roti*, *raksi* and *achar* which are prepared by bride's house (Bisht and Bankoti 2004). Chutney made from salt-free fermented fish product (*Shidal*) is popularly relished by the ethnic communities of Tripura, Assam, Mizoram, Arunachal Pradesh and Nagaland; that is usually served during traditional festivals (Majumdar et al. 2016).

There are a number of pickled items in the Himalayan region that differs from one place to other in their composition and sometimes in the method of preparation. Although, the basic techniques and principle of pickle production is more or less similar; the pickled products are hugely diverse in the types of ingredients being used that truly reflects the food habit of an individual community that have remained geographically isolated in the past for thousands of years (Table 1). Preparation of pickle in its true sense is an art that has been nurtured by these communities for ages which is evident from the fact that each and every individual of a family is somehow associated with the preparation process. The cultural influences could also be observed with the unique and rare pickled items of a community which clearly indicates the constant urge for the refinement of the art of pickling that has been truly treasured by them driven by their palatability and sensory values. Several modifications have also been made during ages accordingly in different cultures based up on the availability of raw materials.

There are numerous pickles that exemplify this statement, for example unripe fruits of *lasora* (*Cordia dichotoma*) which is indigenous to the Western Himalayas are used to prepare pickle by removing the seeds (Sharma and Singh 2012). Various indigenous fruits and vegetables like *beedana* (*Cydonia oblonga*), *aaroo* (*Prunus persica*), *kachnar* (*Bauhinia variegata*) etc. are also preserved in the form of pickles in Himachal Pradesh of Western Himalayas that are served as good appetizers (Monika et al. 2016). A wide range of local herbs and spices are mixed with the raw ingredients and preserved in mustard oil and lime juice

Table 1 List of important plants/plant parts used in the preparation of traditional pickles in the Himalayan and adjacent hilly regions

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Acacia rugata</i> (Lam.) Fawc. & Rendle Family: Leguminosae	Sikakai, Aila, Lashiur	NS	Young shoots	Nepal	Uprety et al. (2012)
<i>Agaricus bisporus</i> Family: Agaricaceae (Fungi)	Lolam	Nyishi tribe	Whole plant body	Arunachal Pradesh (India)	Gangwar et al. (2015)
<i>Alocasia navicularis</i> (K. Koch & C.D. Bouche) K. Koch & C.D. Bouche Family: Araceae	Mane	Nyishi tribe	All parts	Arunachal Pradesh (India)	Gautam et al. (2004)
<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicolson Family: Araceae	Ole	NS (for Nepal), Nyishi tribe	Root	Nepal; Arunachal Pradesh (India)	Bhattarai (1991), Gangwar et al. (2015)
<i>Antidesma acidum</i> Retz. Family: Phyllanthaceae	Dakhi	NS	Young leaves	Nepal	Uprety et al. (2012)
<i>Antidesma montanum</i> Blume Family: Phyllanthaceae	Archal	NS	Young leaves	Nepal	Acharya and Acharya (2010)
<i>Aralia leschenaultii</i> (DC.) J. Wen Family: Araliaceae	Chinday	NS	Young shoots	Nepal; Sikkim (India)	Sundriyal et al. (1998), Tamang and Thapa (2014)
<i>Artocarpus heterophyllus</i> Lam. Family: Moraceae	Katahal, Belang	Adi tribe	Unripe fruits	Arunachal Pradesh (India)	Kumar et al. (2015a, b)
<i>Artocarpus lacucha</i> Buch.-Ham. Family: Moraceae	Dheu, Badar	NS	Unripe fruits	Himachal Pradesh, Sikkim (India); Southern Nepal	Rai and Rai (1994), Gautam et al. (2004)
<i>Asparagus racemosus</i> Willd. Family: Asparagaceae	Kurilo, Jhirjhirekanda, Kurla	NS	Tender shoots	Nepal	Uprety et al. (2012)
<i>Bambusa tulda</i> Roxb. Family: Poaceae	Tama	NS	Young shoots	Sikkim (India)	Tamang and Thapa (2014)
<i>Bauhinia variegata</i> L. Family: Leguminosae	Koirala, koilar, Kachnar	NS	Flower buds, Pods	Sikkim, Himachal Pradesh, Jammu & Kashmir (India); Some parts of Nepal	Acharya and Acharya (2010), Uprety et al. (2012), Malla et al. (2014)
<i>Benincasa hispida</i> (Thunb.) Cogn. Family: Cucurbitaceae	Kubhindo	NS	Fruits	Nepal	Uprety et al. (2012)

Table 1 continued

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Caltha palustris</i> L. Family: Ranunculaceae	Horgul	NS	Young flower tops	Parvati valley in Himachal Pradesh (India)	Sharma et al. (2010)
<i>Cannabis sativa</i> L. Family: Cannabaceae	Gaanja, Ganja, Bhang	Gurung, Mangar, Majhi community	Roasted seed	Gauriganj and Jhapa (Nepal)	Malla et al. (2014)
<i>Capparis spinosa</i> L. Family: Capparaceae	Baganchuwa	NS	Young shoots	Nepal	Uprety et al. (2012)
<i>Capsicum annum</i> L. Family: Solanaceae	Pettang Misi, Chukh	Adi, Nocte and Wancho	Fruits	Arunachal Pradesh, Himachal Pradesh (India)	Tangjang et al. (2014), Bhuyan and Teyang (2015)
<i>Capsicum chinense</i> Jacq. Family: Solanaceae	Sibol Misi, Dalle khorsani	Adi tribe; Nepali community	Fruits	Arunachal Pradesh, Darjeeling, Sikkim (India)	Tamang and Thapa (2014), Tangjang et al. (2014)
<i>Choerospondias axillaris</i> (Roxb.) B.L. Burtt & A.W. Hill Family: Anacardiaceae	Lapsi	NS	Fruits	Sikkim, Darjeeling (India); Kavrepalanchowk District (Nepal)	Chhetri and Gauchan (2007), Malla et al. (2014), Singh et al. (2014), Mahato and Chhetri (2015)
<i>Cissus javana</i> DC. Family: Vitaceae	Jogilahara	NS	Leaves	Nepal	Uprety et al. (2012)
<i>Citrus macroptera</i> Family: Rutaceae	Soh Kwit, Chambal	Khasi and Garo tribe	Pulp, Whole Fruits	Meghalaya (India)	Upadhaya et al. (2016)
<i>Colocasia esculenta</i> (L.) Schott Family: Araceae	Kachalu, Taro, Kacchu	NS	Tuber, Petioles	Bilaspur District (Nepal)	Bhattarai (1991), Gautam et al. (2004), Monika et al. (2016)
<i>Cordia myxa</i> L. <i>Cordia dichotoma</i> G. Forst. Family: Boraginaceae	Lasora	NS	Fruits	Sewa catchment area in Jammu & Kashmir (India)	Khan et al. (2009), Sharma and Singh (2012), Khan and Hussain (2014), Monika et al. (2016)
<i>Crateva religiosa</i> G. Forst. Family: Capparaceae	Shiplikan	NS	Leaf bud	Durbar Devasthan, Gulmi (Nepal)	Gautam et al. (2004)
<i>Cucumis sativus</i> (L.) Family: Cucurbitaceae	Kakra, Khalpi, Adhai	Thangmi community	Mature and ripened fruits	Darjeeling, Sikkim (India); Nepal	Turin (2003)
<i>Cydonia oblonga</i> Mill. Family: Rosaceae	Beedana	NS	Fruits	Kullu in Himachal Pradesh (India)	Monika et al. (2016)
<i>Dendrocalamus hamiltonii</i> Nees and Arnott Family: Poaceae	Mesu, Dibang, Iiting, Ikung	Limboo tribe; Adi tribe	Shoots	Darjeeling, Sikkim, Arunachal Pradesh (India)	Acharya and Acharya (2010), Kumar et al. (2015a, b)

Table 1 continued

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Dendrocalamus strictus</i> (Roxb.) Nees Family: Poaceae	Bans	NS	Mature stem	Sewa catchment area in Jammu & Kashmir (India)	Khan et al. (2009), Khan and Hussain (2014)
<i>Desmodium oojeinense</i> (Roxb.) H. Ohashi Family: Leguminosae	Sadhan, Panan	NS	Flower	Rupandehi District (Nepal)	Acharya and Acharya (2010)
<i>Dillenia indica</i> L. Family: Dilleniaceae	Outenga, Chompa, Somp	Adi tribe	Unripe fruits	Arunachal Pradesh (India)	Kumar et al. (2015a, b)
<i>Diplazium esculentum</i> (Retz.) Sw. Family: Athyriaceae	Lingri, Lingra	NS	Young fronds, Leaves	Kullu, Chamba, Solan, Shimla in Himachal Pradesh, Poonch District in Jammu & Kashmir (India)	Sharma et al. (2009), Monika et al. (2016)
<i>Diplazium frondosum</i> C. Chr. Family: Athyriaceae	Khandhor, Kasror	NS	Young leaves	Sewa catchment area in Jammu & Kashmir (India)	Khan et al. (2009), Khan and Hussain (2014)
<i>Docynia indica</i> (Wall.) Decne. Family: Rosaceae	Chipfoshi, Phosi, Theithup	Nagas and Kukis	Ripe fruits	Nagaland, Manipur (India)	Pfoze et al. (2011)
<i>Dryopteris cochleata</i> (D. Don) C. Chr. Family: Dryopteridaceae	Niuro, Kochiya	NS	Tender leaves	Rupandehi District (Nepal)	Acharya and Acharya (2010)
<i>Duchesnea indica</i> (Jacks.) Focke Family: Rosaceae	Bhui Kapal	NS	Fruits	Darjeeling (India)	Mahato and Chhetri (2015)
<i>Elaeagnus latifolia</i> L. Family: Elaeagnaceae	Musleri	NS	Fruits	Darjeeling (India)	Mahato and Chhetri 2015
<i>Elaeagnus rhamnoides</i> (L.) A. Nelson Family: Elaeagnaceae	Cherma	NS	Fruits	Spiti valley (India)	Singh et al. (2012)
<i>Elaeagnus umbellata</i> Thunb. Family: Elaeagnaceae	Ghain, Ginhin	NS	Fruits	Himachal Pradesh, Sikkim, Darjeeling, Meghalaya (India)	Singh and Thakur (2014), Singh et al. (2014)
<i>Eriolobus trilobatus</i> (Labill. ex Poir.) M. Roem. Family: Rosaceae	Mehel	NS	Fruits	Sikkim, Darjeeling (India)	Sundriyal et al. (1998), Singh et al. (2014), Mahato and Chhetri (2015)
<i>Eryngium foetidum</i> L. Family: Apiaceae	Brahma dhanian	NS	Leaves	Sikkim (India)	Gautam et al. (2004)

Table 1 continued

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Evodia fraxinifolia</i> (Hook.) Benth. Family: Rutaceae	Khanakpa	NS	Fruits	South western Himachal Pradesh (India)	Gautam et al. (2004)
<i>Ficus hispida</i> L.f. Family: Moraceae	Thote, Khasreto	NS	Fruits	Nepal	Uprety et al. (2012)
<i>Ficus lacor</i> Buch.-Ham. Family: Moraceae	Kabhro, Kapara	Gurung, Magar, Majhi community	Flowers, Young buds and Leaves	Gauriganj & Jhapa District (Nepal)	Gautam et al. (2004), Acharya and Acharya (2010), Malla et al. (2014)
<i>Ficus virens</i> Aiton Family: Moraceae	Kabra, Kunhip	Lepcha community	Unopened leaf buds	Sikkim (India)	Rai and Rai (1994), Tamang and Thapa (2014)
<i>Glycine max</i> (L.) Merr Family: Leguminosae	Bhatmas, Aakhone, Tungrymbai	Nepali, Khasi and Garo	Seeds	Sikkim, Nagaland, Meghalaya (India)	Tamang and Thapa (2014), Tamang (2015)
<i>Guizotia abyssinica</i> (L.f.) Cass. Family: Asteraceae	Philingo	NS	Seeds	Sikkim, Darjeeling (India)	Tamang and Thapa (2014)
<i>Heracleum wallichii</i> DC. Family: Apiaceae	Chimpring	NS	Dried flowers, Fruits	Sikkim, Darjeeling (India)	Tamang and Thapa (2014), Sundriyal et al. (1998)
<i>Hydnum repandum</i> L. Family: Hydnaceae (Fungi)	Chyau	NS	Whole plant body	Nepal	Uprety et al. (2012)
<i>Indigofera atropurpurea</i> Hornem. Family: Leguminosae	Sakhino, Jhimiliya	NS	Flowers	Rupandehi District (Nepal)	Acharya and Acharya (2010)
<i>Litsea cubeba</i> (Lour.) Pers. Family: Lauraceae	Siltimbur	NS	Fruits	Sikkim, Darjeeling (India)	Sundriyal et al. (1998), Tamang and Thapa (2014)
<i>Livistona jenkinsiana</i> Griff. Family: Arecaceae	Tokopatta	Adi tribe	Leaves	Arunachal Pradesh (India)	Kumar et al. (2015a, b)
<i>Lycopersicon esculentum</i> Mill. Family: Solanaceae	Tamatar	NS	Unripe fruits	Kullu in Himachal Pradesh (India)	Monika et al. (2016)
<i>Mahonia napaulensis</i> DC. Family: Berberidaceae	Chitre	Gurung, Magar, Majhi community	Ripe Fruits	Gauriganj and Jhapa District (Nepal)	Malla et al. (2014)
<i>Mangifera indica</i> L. Family: Anacardiaceae	Aamp, Sathak, Aam	NS	Fruits	Nepal; Himachal Pradesh (India)	Gautam et al. (2004), Acharya and Acharya (2010), Uprety et al. (2012)
<i>Mentha spicata</i> L. Family: Lamiaceae	Pudina	NS	Leaves	Rupandehi District, Nepal	Gautam et al. (2004), Acharya and Acharya (2010)]

Table 1 continued

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Nelumbo nucifera</i> Gaertn. Family: Nelumbonaceae	Thambal	NS	Young leaves, Roots	Arunachal Pradesh (India)	Gangwar et al. (2015)
<i>Oxalis corniculata</i> L. Family: Oxalidaceae	Charia milo	NS	Vegetative parts	Rupandehi District, Nepal	Acharya and Acharya (2010)
<i>Parkia timoriana</i> (DC.) Merr. Family: Leguminosae	Yongchak	Meitei tribe	Tender pods	Manipur (India)	Singh et al. (2007)
<i>Perilla frutescens</i> (L.) Britton Family: Lamiaceae	Nambongmuchi, Silam	Limboo tribe	Roasted seeds	Sikkim (India); Nepal	Uprety et al. (2012), Tamang and Thapa (2014)
<i>Phyllanthus emblica</i> L. Family: Phyllanthaceae	Aonla, Amala, Aura	Naga, Kuki, Adi tribe	Fruits	Manipur, Jammu & Kashmir (India); Nepal	Acharya and Acharya (2010), Pfoze et al. (2011), Uprety et al. (2012), Malla et al. (2014), Khan and Hussain (2014)
<i>Pisum sativum</i> L. Family: Leguminosae	Kegu	Newar community	Seeds	Sikkim (India)	Tamang and Thapa (2014)
<i>Polygonum molle</i> D. Don Family: Polygonaceae	Thotne	Newar community	Young shoots	Sikkim (India)	Tamang and Thapa (2014)
<i>Praecitrullus fistulosus</i> (Stocks) Pangalo Family: Cucurbitaceae	Tinda	Nyishi tribe	Tender Fruits	Arunachal Pradesh (India)	Gangwar et al. (2015)
<i>Prunus persica</i> (L.) Batsch Family: Rosaceae	Aaroo	NS	Fruits	Kullu in Himachal Pradesh (India)	Monika et al. (2016)
<i>Pteridium aquilinum</i> (L.) Kuhn Family: Dennstaedtiaceae	Kakaie	NS	Rhizome, Young leaves	Poonch District in Jammu & Kashmir (India)	Khan et al. (2009)
<i>Pyrus communis</i> L. Family: Rosaceae	Nashpati	NS	Unripe fruits	Kullu in Himachal Pradesh (India)	Monika et al. (2016)
<i>Rhododendron arboreum</i> Sm. Family: Ericaceae	Gurans	NS	Flowers	Nepal	Bhattarai (1991)
<i>Ribes alpestre</i> Wall. ex Decne. Family: Grossulariaceae	Masino Kimbu	Lepcha	Fruits	Uttarakhand, Himachal Pradesh (India); Nepal	Kumar et al. (2015a, b)
<i>Ricinus communis</i> L. Family: Euphorbiaceae	Ander, Aril, Raine	NS	Fruits	Nepal	Uprety et al. (2012)

Table 1 continued

Scientific name of plant	Vernacular name of pickle/plant used	Specific community/tribe associated	Plant part(s) used for pickling	Geographical location/region	References
<i>Rohdea nepalensis</i> (Raf.) N. Tanaka Family: Asparagaceae	Nakima	Bhutia, Lepcha		Sikkim (India)	Tamang and Thapa (2014)
<i>Sechium edule</i> (Jacq.) Sw. Family: Cucurbitaceae	Chocho	NS	Fruits	Nepal	Bhattarai (1991)
<i>Senna tora</i> (L.) Roxb. Family: Leguminosae	Elon	NS	Seed	Kangra and Chamba valley in Himachal Pradesh (India)	Monika et al. (2016)
<i>Smilax zeylanica</i> L. Family: Smilacaceae	Kukur daine	NS	Fruits	Sikkim, Himachal Pradesh (India); Nepal	Uprety et al. (2012), Tamang and Thapa (2014)
<i>Solanum betaceum</i> Cav. Family: Solanaceae	Rukh tamatar	NS	Fruits	Sikkim, Darjeeling (India); Nepal	Singh et al. 2014
<i>Solena heterophylla</i> Lour. Family: Cucurbitaceae	Ban khira	NS	Fruits	Gauriganj and Jhapa District, Nepal	Gautam et al. (2004)
<i>Tamarindus indica</i> L. Family: Leguminosae	Imili	NS	Fleshy fruit pulp	Rupandehi District (Nepal)	Acharya and Acharya (2010)
<i>Thelypteris</i> spp. Family: Thelypteridaceae	Neuro	NS	Tender leaves	Nepal	Gautam et al. (2004)
<i>Thymus serpyllum</i> L. Family: Lamiaceae	Merchari	NS	Seeds	Sewa catchment area in Jammu & Kashmir (India)	Khan et al. (2009), Khan and Hussain (2014)
<i>Trichosanthes cucumerina</i> L. Family: Cucurbitaceae	Chachinde	NS	Tender Fruits	Arunachal Pradesh (India)	Gangwar et al. (2015)
<i>Zanthoxylum armatum</i> DC. Family: Rutaceae	Boke timbur	NS	Fruits	Sikkim, Darjeeling (India); Nepal	Gautam et al. (2004), Malla et al. (2014)
<i>Zanthoxylum oxyphyllum</i> Edgew. Family: Rutaceae	Laharay Timbur	NS	Fruits, Seeds	Sikkim (India)	Tamang and Thapa (2014)

NS not specific, no specific tribe/community could be assigned

(Monika et al. 2016). Consumption of bamboo shoots in the form of pickle is very popular practice in both Western and Eastern Himalaya. Adi tribes of Arunachal used to make pickles from bamboo shoots locally known as Dibang, Iiting, Ikung (Kumar et al. 2015a, b). On the contrary, mature shoots are used in making pickle in

Jammu and Kashmir (Khan and Hussain 2014). Dried, crushed and salted caterpillars along with ginger and garlic paste are made into chutney which is very unique to Naga cuisine (Singh et al. 2007). Khasi and Garo tribes of Meghalaya prepared pickles from *Citrus macroptera*, a wild citrus, but in different ways. Khasi people take the

sun-dried pulp and mix it with oil and other spices, whereas in Garo cuisine, the fruit is peeled, cut into small pieces, sun-dried, preserved in glass bottle with mustard oil and other locally available spices and finally again left in sun for fermentation (Upadhaya et al. 2016).

There is a common trend of using ferns in pickle preparation in both Western and Eastern Himalaya. Rhizomes, leaves of *Pteridium aquilinum*, *Diplazium esculentum*, *Thelypteris* spp etc. are used for pickling (Sharma et al. 2009; Negi and Subramani 2015). In Papum Pare District of Arunachal Pradesh, a mushroom (*Agaricus bisporous*) is also consumed as pickle (Gangwar et al. 2015). Another fungus, named *Chyau* (*Hydnum repandum* L.) is used for pickle making in Nepal (Upreti et al. 2012). In general, fruits (ripe and unripe) are the main ingredients of pickle making in most of the cases, but the other parts viz. rhizomes of *Bergenia pacumbis* (*Pashanbheda*), *Pteridium aquilinum* (*Kakaie*), leaves of *Eryngium foetidum* (*Brahma dhania*), *Antidesma acidum* (*Dakhi*) etc., flowers of *Indigofera atropurpurea* (*Sakhino*), *Caltha palustris* (*Horgul*), *Rhododendron arboreum* (*Gurans*) etc., seeds of *Senna tora* (*Elon*), *Glycine max* (*Bhatmas*), *Thymus serpyllum* (*Merchari*) etc. are also frequently utilized as outlined in Table 1. Some plant/plant parts which are not usually consumed as vegetable are also frequently pickled, for instance, *Nelumbo nucifera* (*Thambal*), *Oxalis corniculata* (*Charia milo*) and *Cannabis sativa* (*Ganja*) in the Eastern Himalayas.

Types and varieties of traditional pickles

In the Himalaya and the adjacent hilly regions of Indian subcontinent, a considerable number of fruits and vegetables are used in pickles. Apart from this, a wide range of fish and meat pickles are also popular in this region. It is rather impossible to categorize pickles of this region due to the wide variety of regional recipes, though we could broadly classify them as fermented and non-fermented

based on whether fermentation is involved in pickling process or not (Fig. 1). Fermented pickles are generally preferred by producers and consumers due to their longer shelf life, good taste and aroma (Tamang and Tamang 2009). Fermented pickles can be further categorized into pre- and post-fermented. The generalised outline of pickle production is outlined in Fig. 2.

The overdominance of the usage of fermented food products in pickle preparation in this region makes it unique which could be greatly attributed to the sensory values and the prevalence of fermentation techniques among the local tribes and communities for ages. The fermented bamboo shoot pickle, *mesu*—a pre-fermented pickle [a Limboo word literally meaning young bamboo shoot (*me*) and sour (*su*)] in Nepal, Darjeeling and Sikkim region is prepared from fermented young bamboo shoots with oil, chillies and salt which can be preserved for long time (Tamang 2010). Similarly, *soibum* and *soidon* are two such pre-fermented bamboo shoot pickle which are also taken as curry (Choudhury et al. 2012). Fermented soybean is another popular substrate for pickle production in North-eastern states of India. In Manipur, *Hawaijar* (fermented soyabean seeds) are fried with oil and spice and stored in sealed bottle for a long time (Devi and Kumar 2012). Sticky fermented soya seed *tungrymbai* is also used for pickle making by Garo and Khasi people in Meghalaya with addition of ginger, garlic, oil etc. (Tamang 2010). Another fermented soya product, *tungtoh* is made into pickle by Jaintia community (Tamang et al. 2012). Similarly, freshly fermented soya seeds *Aakhone* along with green chillies, tomato and salt are popular pickle of Sema tribes of Nagaland (Tamang 2010). *Gundruk*, a fermented product prepared from leaves of *Brassica juncea* (*rayo shag*) and other locally available cruciferous vegetables in Sikkim, Darjeeling, Nepal, Bhutan and Arunachal Pradesh of Eastern Himalayas are also used for pickle preparation (Singh et al. 2007; Tamang and Tamang 2010). Also, a fermented radish taproot product of this region, *sinki*, prepared by pit fermentation during winter season is also

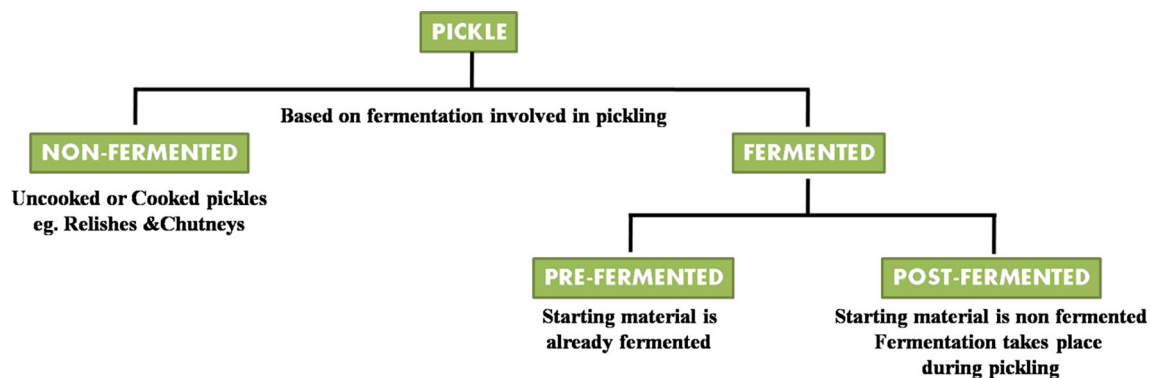


Fig. 1 Broad classification of traditional pickles



Fig. 2 An outline of the generalised method of pickle preparation by the traditional communities in the Himalayan region with photographic representation of the preparation of pickled cucumber (*Khalpi*) in Nepal. **a** Fresh cucumbers, **b** cucumbers being cut and

dried in sun for dehydration; **c, d** cut into smaller pieces and mixed with salt, oil and indigenous spices; **e** canned in plastic containers and put under sun for the fermentation to complete; **f** finished product—*Khalpi ko achar*

used in pickle preparation by drying and mixing with oil, salt and chillies (Tamang 2010). While *sinki* is essentially dry, Gorkha community of Darjeeling, Sikkim, and Nepal also make pickle from fleshy fermented radish, *Sinnamani* (Tamang 2010; Tamang et al. 2012). Pieces of mature and ripened cucumbers are sundried and fermented in closed bamboo vessel called *dhungroo* and finally pickled with mustard oil, salt and powdered chilli (Tamang and Tamang 2010).

The preparation of post-fermented pickles is however very common and almost all the fruits and vegetables available in this region are used for the preparation of pickles. Majority of the post-fermented pickles are prepared using a single fruit or vegetable, however, mixed pickles are also common. Thus to avoid complexity, we have enlisted the main ingredients used in the popularly prepared monotypic pickles, along with the major tribes or communities associated with the preparation (Table 1). Apart from this a wide range of spices based on regional availability are added to impart flavour and aroma to the pickled product (Noonari et al. 2015). The whole seeds of fenugreek, thyme, nigella and fennel are used for flavour

and texture development, whereas turmeric, red chilli and asafoetida powder are added to prevent microbial spoilage (Monika et al. 2016). The use of black salt in addition with crystal salt, aniseed, onion seed, black pepper, *garam masala* (mixture of Indian spices) and mango powder has also been frequently observed.

Apart from the fermented pickles, the pickles are also prepared without the fermentation process being involved in any of the steps. These types of pickles are sometimes referred as instant pickles and include the *chutneys* and *relishes*, which are prepared in a very short time, however have short shelf life usually less than a week. The quality of *chutney* depends on the cooking duration which is long enough below the boiling point to avoid fermentation. The high sugar and acid content of *chutneys* are the basis of preservation and flavour development is achieved by addition of different spices (Rahman et al. 2014). In Uttarakhand state of India, *chutneys* are made from locally available plant parts viz. *darim* (wild pomegranate dry seeds), *til* (sesame seeds), *bhat* (soyabean seeds), *kilmora* (*Berberis* flower buds) etc. and used as supplement with main course dishes or as substitute for vegetables (Mehta et al. 2010). Traditional

Naga *chutney* known as *tathu*, contains some unique indigenous spices like Naga red chilli (one of the world's hottest chilli) and small sized Naga ginger (very useful in curing fever and high blood pressure) (Bhardwaj et al. 2015). In Adi tribe of Arunachal Pradesh, a *chutney* from fermented soya paste (*peron naming*) is prepared by mixing it with tomato paste, chilli, ginger and salt. Sherdukpen tribal women of West Kameng District, Arunachal Pradesh also make soybean-based food called *chukchoro* which is used to prepare *chutney* by using salt, yak cheese, tomato and local chilli (Singh et al. 2007). Pods of another legume, *Parkia timoriana* (*Yongchak*) is used for making *chutney* by Meitei community of Manipur which is useful for treating intestinal disorder (Singh et al. 2007).

Moreover, fish and meat based pickles are also widely popular among the tribes and communities of this region. *Sidra* and *Sukuti* are two important non-fermented fish pickle of the ethnic communities of Nepal, Bhutan, Sikkim and Darjeeling. *Sidra* is a thick pickle paste prepared by mixing dried and roasted *Puntinus sarana* (*Maraputthi*) with boiled tomato, chilli and salt, whereas, *Sukuti* is prepared from sundried and salted *Harpodon nehereus* (*Lutia*) fish by mixing with oil, onion, dry chillies and salt (Tamang 2010; Thapa 2016). *Tungtap*, an indigenous fermented fish paste made by Khasi people of Meghalaya is used for making curry as well as pickle (Thapa 2016). *Shidal chutney*, prepared either from *Puntinus sophore* (*punti shidal*) or from *Setipinna phasa* (*phasa shidal*) has a unique flavour and smell and consumed in Arunachal Pradesh, Mizoram, Nagaland of India (Majumdar et al. 2016; Thapa 2016). *Chutney* prepared from fermented

black crabs in banana leaves with sesame seeds is popularly consumed among the ethnic tribes of Nagaland viz. Lotha, Mao and Angami (Mao and Odyuo 2007). Buffalo and pork meat pickle is also popular in Nagaland (Gaddekar et al. 2010). A brief list of the indigenous fish and meat pickles of this region are also compiled in Table 2.

Beneficial properties conferred by the associated microorganisms

Traditional procedures of pickling and their palatability are hugely dependent on microorganisms. Fermentation plays an important role in the long term preservation of fruits, vegetables and meats that are being pickled. Natural microflora associated with fruits and vegetables under saline or acidic condition and controlled temperature primarily brings about the onset of fermentation (Tamang et al. 2016). During fermentation, organic acids present in the fruits and vegetables slowly diffuses out into the brine solution, resulting in lowering pH and subsequently influences the growth of essential microbes across the surface of the material (Breidt et al. 2013). The major microbial community associated with fermentation include the members of lactic acid bacteria (LAB), some non-lactic bacterial genera and some mycelial fungi (Tamang 2010). LAB induces the rapid accumulation of organic acids like lactic acid, citric acid and acetic acid in the raw materials (Darmayanti et al. 2014). At earlier stages of pickling, when the salt concentration is low, many bacterial genera such as *Pseudomonas*, *Bacillus*, *Flavobacterium* frequently

Table 2 List of some fish/meat based traditional pickles in the Himalayan and adjacent hilly regions

Sl. no.	Name of pickle	Ingredients	Specific community/tribe associated	Geographical location/region	References
1.	Ayaiba	Fish	Meitei	Manipur, Mizoram (India)	Thapa (2016)
2.	Naakangba	Fish	Meitei, Kuki	Manipur, Nagaland (India)	Tamang et al. (2012), Thapa (2016)
3.	Nah-grain	Small fish	NS*	Assam (India)	Thapa (2016)
4.	Shidal	<i>Puntinus sophore</i> ; <i>Setipinna phasa</i>	NS	Tripura, Assam, Mizoram, Nagaland, Arunachal Pradesh (India)	Majumdar et al. (2016), Thapa (2016)
5.	Sidra	<i>Puntius sarana</i> Hamilton	NS	Nepal; Bhutan; Sikkim, Darjeeling (India)	Thapa (2016)
6.	Sukuti	<i>Harpodon nehereus</i> Hamilton	NS	Nepal; Bhutan; Darjeeling (India)	Thapa (2016)
7.	Tungtap	<i>Danio</i> spp	Khasi	Meghalaya (India)	Sekar and Mariappan (2007), Kakati and Goswami (2013), Thapa (2016)
8.	Carabeef	Buffalo meat	Naga	Nagaland (India)	Gaddekar et al. (2010)
9.	Rapka	Yak meat	Naga	Nagaland (India)	Gaddekar et al. (2010)

NS not specific, no specific tribe/community could be assigned

grow in the medium (Shah et al. 2014). Later on, at the onset of high salt concentration, *Streptococcus faecalis* and *Leuconostoc mesenteroides* begin to appear (Sharma 2007). Then *Lactobacillus brevis* grows, producing more acid and *L. plantarum* predominates after the further increase in salt concentration and produces lactic acid. The final fermentation steps are carried out by yeasts accompanied by *Debaryomyces*, *Pichia*, *Candida* and lactic acid concentration begin to decline (Shah et al. 2014; Mokoena et al. 2016). Brines used for pickle fermentation typically contain high concentrations of salt and organic acids having a pH less than 4.5, which is inhibitory to toxic coliforms, pseudomonads, clostridia, and other non-lactic acid bacteria that would result in flavor and texture problems (Sohaib et al. 2016).

Several beneficial microorganisms are associated with traditional pickles and the consumption of them enrich the natural microflora of the gastrointestinal system. Many bacteria viz. *Lactobacillus curvatus*, *Paediococcus pentosaceus*, *Leuconostoc fallax*, *Leuconostoc lactis*, *Enterococcus durans*, *Lactococcus lactis* etc. have been reported to be involved in the production of fermented pickle *Hirring* (bamboo shoot tips), *Khalpi* (cucumber) and *Sinki* (radish tap root) (Tamang et al. 2016). Fermented fish pickle *Tungtap*, prepared from *Puntinus* sp. or *Danio* sp. in North-east India, is produced from the microbial fermentation by *Lactobacillus amylophilus*, *Lactobacillus coryniformis* subsp. *torques*, *Lactobacillus plantarum*, *Lactobacillus fructosus*, *Lactococcus lactis* subsp. *cremoris*, *Lactococcus plantarum*, *Enterococcus faecium*, *Bacillus subtilis*, *Bacillus pumilus*, *Micrococcus*, *Candida* and *Saccharomycopsis* (Kakati and Goswami 2013). *Sidra* pickle harbours the diverse microflora of *Lactococcus lactis* subsp. *cremoris*, *L. lactis* subsp. *lactis*, *Lactobacillus plantarum*, *Leuconostoc mesenteroides*, *Enterococcus faecium*, *E. faecalis*, *Paediococcus pentosaceus*, and *Weissella confusa* and yeasts (*Candida chiropterorum*, *C. bombicola*, and *Saccharomycopsis* spp.) (Thapa 2016). Therefore, the role of microorganisms in the preparation of fermented pickles is highly essential and the association of these microorganisms with the finished product enriches the natural microflora of the gastrointestinal system functioning as potential probiotics. But several studies have also shown the coexistence of several pathogenic bacteria and fungi along with the desirable ones (Perez-Diaz et al. 2013). Since, most of the traditional pickle preparation relies up on ancestral knowledge and the procedures depend up on the fermentation by natural microorganisms without any quality control, there is a high chance of contamination and spoilage by the harmful microorganisms which has been discussed in the later section.

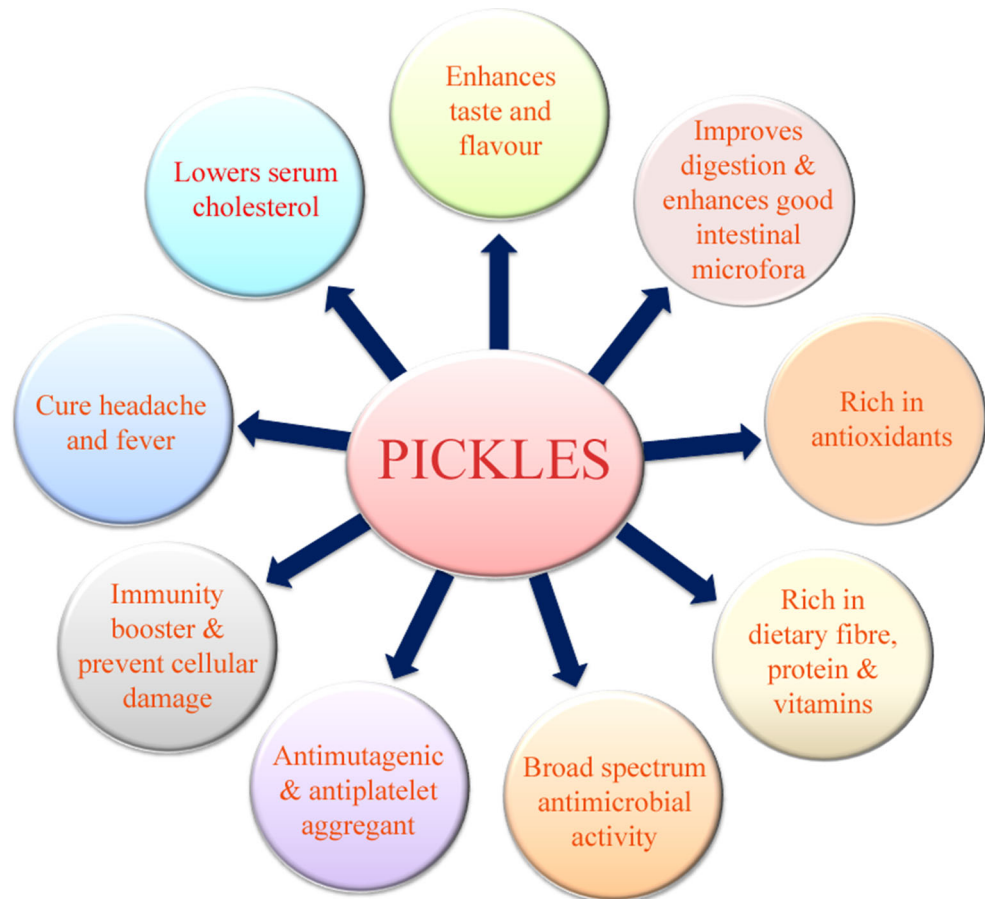
Other beneficial properties and related concerns

The pickles are an integral part of the diet of the tribes and communities of the Himalayan region and there are several health benefits that are being conferred specially by the microorganisms contained in the pickled products. Lactic acid bacteria (LAB) often involved in the preparation steps of fermented pickles are known to control serum cholesterol level as well as prevent tumors by boosting the immune system (Monika et al. 2016). LAB also exhibit antiviral, antiyeast, antimutagenic and antiplatelet aggregation attributes (Kazemipoor et al. 2012). Except for pickles prepared in sugar syrup, most pickles have been reported to lower cholesterol level (Mahalingam 2015). Also, pickling process helps in effective preservation and restoration of natural bioactive compounds and antioxidant capacities of fruits and vegetables (Sayin and Alkan 2015). High levels of proteins, vitamins, and dietary fibres were found during physicochemical characterization of commercial pickled garlic (Casado et al. 2004). Pickles prepared using coloured fruits and vegetables contains pigments such as anthocyanins, flavonoids, carotenoids etc. that are effective in scavenging harmful free radicals in the body produced by different biological stresses and diseases (Swain et al. 2014). It has been reported that high ascorbic acid content of some Indian pickles may inhibit benzene formation and associated cellular damage (Kharat et al. 2016). Intake of a considerable quantity of pickle may relieve the exercise related muscle cramp of athletes by alteration of electrolyte in plasma (Miller et al. 2009). The probable health benefits of the pickles are being outlined in Fig. 3.

Several works have revealed the beneficial properties of traditional pickles. LAB from yellow bamboo (*Dendrocalamus asper*) shoot pickles have shown antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus* (Hartayanie et al. 2016). LAB produce several antimicrobial compounds including organic acids viz. formic, lactic, phenyllactic, acetic and caproic acid thereby preventing mould spoilage. Two strains of LAB viz. *Lactobacillus plantarum* and *Paediococcus pentosaceus* from pickled vegetables, have been used in probiotics to prevent the *Salmonella* invasion in animal metabolism (Irkin and Songun 2012). It has been reported that fermented pickles like *Mesu* is low in cholesterol but contains high amount of dietary fibre, minerals and antioxidant compounds (Joshi 2016). Storage tap roots of radish which is frequently used for making pickle and chutney is believed to be helpful in curing headache and fever during monsoon season (Turin 2003).

The pickling process is associated with conditions most unfavourable for the growth and multiplication of harmful

Fig. 3 Outline of some of the beneficial properties of pickles



microorganisms. But due to some unavoidable circumstances, the stored product may be damaged by the development of undesired colour, taste, odour which make them unsuitable for consumption. Traditional ways of pickling with salt and sun drying and use of several indigenous herbs and spices allow for regulating the contamination by harmful microbes like *Clostridium botulinum* (Lee and Kang 2004). Occasional appearance of wild yeasts and moulds may confer scum formation in pickled product. These fungi retard lactic acid production by enhancing the growth of putrefactive bacteria resulting into white scum formation and lowering the concentration of acetic acid below 4% and sugar below 50%, which is needed to preserve pickles from fungal spoilage (Sperber and Doyle 2009). The presence of microbes like *Staphylococcus aureus*, *Micrococcus*, *Escherichia coli* and species of *Bacillus* prevail in shidal chutney (Thapa 2016). Since, there is no such quality control mechanism in traditionally prepared pickles, the assessment of a well prepared pickle and the status of its wellness is done on the basis of its physical parameters. Cooking time and addition of spices are two important criteria for preparing a good quality pickle. Overcooked items cannot be preserved for a longer time and result in deviation from the usual taste. Similarly,

addition of extra amount of spices can lead to the development of unwanted bitter taste. Also, the presence of rust in iron containers or cooking utensils may result in a blackish colouration of pickle. In general, the pickled items are well immersed in the preservation medium, to avoid contamination with unwanted microorganisms which may lead to softening and slipperiness and can ruin the quality of the final product (Ranganna 1986). Spoilage of pickles is undesirable and therefore should be checked at the time of consumption to avoid the complications caused by harmful microorganisms.

Conclusion

Himalayan region of Indian subcontinent harbours rich diversity of flora and fauna. The people living in and around this area has long been disconnected from the rest of the world due to rough terrains and poor transportation mediums. However, the communities and tribes residing in this region have sustained themselves for thousands of years in this difficult scenario owing to their rich knowledge and art of utilizing the treasures of nature. They have always tried to preserve the excess agricultural products for

the lean periods by the techniques of preservation. Pickling of food items developed gradually as a method of preservation and practically preservation of almost all the type of raw and fresh perishable items have been practised by the people of this region. Pickling has been used to preserve not only the agricultural produces, but also several wild edible plants have been pickled owing to their medicinal and beneficial properties. Also, several fish and meat products have been pickled as a source of proteins for the climatically unfavourable seasons. Therefore, method of pickling involving indigenous microorganisms has always been popular among the people of this region. Pickles are a potent source of probiotic microbes and thus relevant in commercialization and dispersion of traditional knowledge of Himalayan ethnic groups worldwide.

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