Naturally fermented ethnic soybean foods of India

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ARTICLE INFO
Article history:
Received 15 January 2015
Received in revised form
22 January 2015
Accepted 6 February 2015
Available online 26 February 2015

Keywords:
Bacillus
ethnic foods
kinema
naturally fermented soybeans

ABSTRACT
Kinema, hawaijar, tungrymbai, bekang, aakhone, and peruyaan are naturally fermented ethnic soybean foods of India; they are popular among the Mongolian-origin races in the Eastern Himalayas. Bacillus subtilis is the dominant functional bacterium in all naturally fermented soybean foods of these regions. Although there is a good demand for ethnic fermented soybean foods among local consumers in north-east India, the production is limited to household level. A ready-to-use pulverized starter culture for kinema production can be introduced to kinema-makers or similar sticky fermented soybean foods of north-east India and adapted to local conditions for additional income generation. Ethnic fermented soybeans are one of the major food resources in the Eastern Himalayas; they supplement inexpensive, high-digested plant protein in the local diet with low fat/cholesterol content and high nutritive value as well as antioxidant and other health-promoting properties.

1. Introduction

In the Eastern Himalayas, soybean [Glycine max (L.) Merrill, family Leguminosae, sub-family Papilionaceae] is grown under rain-fed conditions in upland terraces as a sole crop as well as a mixed crop with rice and maize up to an elevation of 1500 m (Fig. 1). Soybean, locally known as bhatma in Nepali language, is traditionally used to prepare various fermented and nonfermented recipes in the Eastern Himalayan regions of Nepal, India, and Bhutan [1]. Soybean was probably introduced into India from China through the Himalayas several centuries ago and some believe that soybeans were also brought via Myanmar by traders from Indonesia [2]. Two indigenous varieties of soybeans “yellow cultivar” and “dark brown cultivar” (Fig. 1) are grown between May and June and harvested in November. Locally grown soybeans are harvested, and the dry seeds of soybeans are naturally fermented into a flavorful and sticky product in eastern parts of Nepal, Darjeeling hills, Sikkim, north-eastern regions of India, and southern parts of Bhutan close to the Mongolian races. Some of the common ethnic nonsalted sticky fermented soybean foods of the Eastern Himalayas are kinema (Nepal, Darjeeling hills, Sikkim, and south Bhutan), hawaijar (Manipur), tungrymbai (Meghalaya), bekang (Mizoram), aakhone (Nagaland), and peruyaan (Arunachal Pradesh) (Table 1). This article will examine the characteristics, microbiology, and health benefits of kinema as well as hawaijar, tungrymbai, bekang, aakhone, and peruyaan.

2. Kinema production

Kinema is an ethnic fermented soybean food of the Nepali community in the Eastern Himalayas; it is a sticky, slightly alkaline product with a slight ammoniacal flavor that is produced by natural fermentation. It is a whole-soybean fermented food with a sticky texture, gray tan color, and is flavorsome [8]. During traditional production of kinema, the small-sized (~6 mm) “yellow cultivar” soybean dry seeds are selected, washed, and soaked overnight (8–10 h) in water. Soaked soybean seeds are taken out and put into a container with fresh water, and boiled for 2–3 hours until they are soft. Excess water is drained off and the cooked soybean seeds are placed into a wooden mortar (locally called “okhli”) and are cracked lightly using a wooden pestle (locally called “muslo”) to split the cotyledons. This practice of cracking the cooked seeds of soybean is observed only during kinema production, unlike other similar fermented soybean foods of Asia and north-east India, probably to increase the surface area for speed fermentation by aerobic spore-forming Bacillus spp. Approximately 1% of firewood ash is added directly to the cooked soybeans and mixed thoroughly to maintain the alkaline condition of the product. Soybean grits are placed in a bamboo basket lined with locally grown fresh fern called (Glaphylopteriolopsis erubescens). The basket is covered with
a jute bag and left to ferment naturally at ambient temperatures (25–40°C) for 1–3 days above an earthen kitchen oven (Fig. 2). During summer, the fermentation time may require 1–2 days whereas in winter it may require 2–3 days. In eastern Nepal, local consumers prepare dark brown local varieties of soybean seeds rather than yellow-colored seeds for making kinema [9]. Similarly, they commonly use Ficus (fig plant) and banana leaves as wrapping materials instead of fern fronds. Other methods remain the same. Completion of fermentation is indicated by the appearance of a white viscous mass on the soybean seeds and the typical kinema flavor with a slight odor of ammonia.

The shelf-life of freshly prepared kinema (Fig. 3) is 2–3 days in summer and a maximum of 1 week in winter without refrigeration. It may be prolonged by drying in the sun for 2–3 days. Dried kinema is stored for several months at room temperature. Preparation of kinema varies from place to place and is still restricted at the household level. It is interesting to note that mountain women use their indigenous knowledge of food production to prepare kinema. This unique knowledge of kinema-making has been protected as an hereditary right and passed from mother to daughter, mostly among the Limboo.

Kinema is eaten as curry with steamed rice. The delicacy of kinema can be perceived by its appealing flavor and sticky texture. Fresh kinema is fried in vegetable oil, with chopped onions, tomatoes, and turmeric powder. Salt and sliced green chillies are added and fried for 3–5 minutes. A little water is added to make

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thick gravy, and cooked for 5–7 minutes then the kinema curry (Fig. 3) is ready for serving with steamed rice. Dried kinema is sometimes mixed with leafy vegetables to make a mixed curry. Consumers like kinema mostly because of its typical flavor and sticky texture, and some people dislike the product due to its strong umami-type flavor [10] and mucilaginous texture.

Kinema production is a source of marginal income generation for many families in the Eastern Himalayas. Kinema is sold by rural women in all local periodical markets, locally called “haats”, in eastern Nepal, Darjeeling hills, Sikkim, and southern parts of Bhutan. Usually, it is sold by volume taken in a small silver mug containing 150–200 g of kinema, and packed in the leaves of a fig plant (Ficus hookeriana) locally called “nevara”, and then tied loosely by straw. Poly-bags are not used to pack kinema. One kilogram of kinema costs about Rs. 100. An average of 5 kg of kinema is sold by each seller in a local market and about 60% of expenses are incurred on the purchasing of raw soybeans, fuel for cooking, transportation from village to market, etc., and 40% profit is made [1]. This profit is spent on childrens’ education, procuring essential commodities not locally available, and other domestic expenses. Although there is good demand for kinema in the local markets, the production of kinema is still confined to home production; there is no organized processing unit or factory for kinema production. Kinema-making technology has not been recognized as a small-scale industry for receiving financial support or a loan from any public sector bank or financial institution; neither has it been incorporated in the rural development programs of the government in Nepal, India, and Bhutan.

3. Microbiology of kinema

Several species of Bacillus have been isolated from kinema including Bacillus subtilis, Bacillus licheniformis, Bacillus cereus, Bacillus circulans, Bacillus thuringiensis, and Bacillus sphaericus at an average load of 10^8 colony-forming units (CFU)/g [6,8,11]. However, B. subtilis is the dominant functional bacterium in kinema [12,13]. Besides Bacillus, Enterococcus faecium (10^7 CFU/g) and the yeasts Candida parapsilosis and Geotrichum candidum (10^4 CFU/g) have also been reported in kinema [6,7].

Rich microbial diversity is observed in various sources of soybean. The equipment and leaves used as wrapping materials harness microbiota for natural fermentation of kinema [7]. With the decline in protein nitrogen content, the nonprotein and soluble nitrogen contents increase during kinema fermentation [14] and a significant increase in the relative viscosity of kinema is found during maturation at 5°C and 10°C [15]. Keeping freshly prepared kinema below 10°C for 1 day stabilizes the quality of the product by preventing further biological activity of microorganisms and shows better stickiness, which is a very important sensory property of kinema [15]. Organoleptically, the monoculture fermentation of soybean by B. subtilis MTCC 2756 produces the best kinema because of a pleasant nutty flavor and highly sticky texture, and also

**Fig. 2.** Flow diagram of the traditional method of kinema production in Sikkim village, India.
minimizes the conventional fermentation time, maintains better hygienic conditions and consistency, and increases the levels of soluble protein [16].

Inexpensive soybean extract broth after adjusting pH to 7 as a medium is prepared for enrichment of *B. subtilis* spores instead of discarding the soybean extract after autoclaving soybeans [16]. Moreover, nutrient broth, conventionally used for enrichment of *B. subtilis* spores, is composed of expensive beef extract, which is not acceptable to the majority of the Hindu population in the Himalayas. *Kinema* prepared using the *B. subtilis* KK2:B10 strain that is harvested in soybean extract broth is dried in an oven at 70°C for 10 hours and ground aseptically to make pulverized starter. The 1% of pulverized starter instead of *B. subtilis* is added aseptically to autoclaved soybeans and fermented to obtain *kinema*. Consumer preference trials show that *kinema* prepared using pulverized starter under optimized conditions is more acceptable than market *kinema* [16]. Water-soluble nitrogen and formol nitrogen contents are higher in *kinema* prepared using pulverized starter than market *kinema* [16]. Increased water-soluble nitrogen in *kinema* helps with digestibility and the high amount of formol nitrogen, which contains free amino acids supplements, imparts a better taste to *kinema* [17]. Application of ready-to-use pulverized starter may appear appropriate in *kinema* production for marginal *kinema* producers in the Himalayas because it is cost-effective and easy to handle [1]. In 2012, we obtained an Indian Patent on “A process for production of *kinema*, fermented soybean food, using a pure starter culture” (Patent No: 25346).

Although *E. faecium* does not add any sensory quality to the *Bacillus* fermentation of soybeans, it is always encountered in naturally fermented *kinema* [1]. The presence and growth of yeast during *kinema* preparation are associated with the development of rancidity in the products. In fact, *B. subtilis* is the sole fermenting organism in *kinema* preparation.

4. Health benefits of *Kinema*

*Kinema* has many health-promoting benefits including antioxidant, digested protein, essential amino acids, vitamin B complex, low-cholesterol content, etc. [1]; it is therefore considered a functional food. *Kinema* is the cheapest source of plant protein compared to milk and animal products on the basis of protein cost per kilogram. It contains all essential amino acids [18], and is rich in linoleic acid, an essential fatty acid [19]. Total amino acids, free amino acids, and mineral contents are increased during *kinema* fermentation [14,15,17]. Phytosterols (cholesterol-lowering effect) are increased during *kinema* fermentation [19]. Riboflavin and niacin increases in *kinema* during fermentation [20]. *Kinema* has antioxidant activities [21]. Due to the presence of a large amount of Group B saponins, *kinema* claims to have health-promoting benefits [22].

5. Other fermented soybean foods of north-east India

Many *kinema*-like sticky naturally fermented soybeans are consumed by different ethnic communities living in the north-eastern part of India bordering with Bhutan, China, and Myanmar (Fig. 4)—these include *hawaijer* in Manipur, *bekang* in Mizoram,
peruvaan in Arunachal Pradesh, aakhone in Nagaland, and tungrymbai in Meghalaya (Fig. 5).

5.1. Hawaijar

Hawaijar is a traditional fermented soybean alkaline food of Manipur. It is prepared from the local variety of small-seeded soybean grown in the hilly terraces of Manipur [23]. It is similar to kinema. Small-sized soybean seeds are selected, washed, and boiled in an open cooker for 2–3 hours. Excess water is drained off, cooled to ~40°C, and then the whole soybean seeds are packed in a small bamboo basket that has a lid. The basket is lined with fresh leaves of the fig plant (*Ficus hispida*), locally called “assee heibong” in the Meitei language, or banana leaves. After placing cooled soybean seeds inside the basket, the lid is closed loosely and the basket is kept near the kitchen or a warm place for natural fermentation for 3–5 days (Fig. 6). The emission of the typical ammonia odor and appearance of sticky texture on the cooked soybean seeds are determined as good quality hawaijar by the Meitei. The shelf-life of hawaijar is a maximum of 7 days without refrigeration. Sometimes, it is sun-dried for 2–3 days and stored for several weeks for future consumption. Unlike kinema, the practice of cracking and the addition of ash is not adopted by the Meitei women in hawaijar production. Hawaijar is produced by the Meitei women, and the men support the process.

A special curry called “chagempomba” is commonly prepared by the Meitei in Manipur and is eaten with steamed rice. Hawaijar is eaten directly or used as a condiment or mixed with vegetables to make curry in the Manipuri cuisine. Hawaijar is commonly sold in local markets throughout Manipur by the Meitei women. Despite its popularity, there is no organized food sector for mass-scale production of hawaijar in Manipur. The product is still prepared at home and many women are dependent upon the product for their livelihood.

5.2. Tungrymbai

Tungrymbai is an ethnic fermented soybean food of Khasi and Garo in Meghalaya. It is similar to kinema. Soybean seeds are collected, cleaned, washed, and soaked in water for approximately 4–6 hours [24]. The seed coat of the soybean is normally removed before cooking by rubbing the soaked seeds gently. The soaked soybeans are cooked for about 1–2 hours until all the water is absorbed. Cooked beans are allowed to cool, and then they are packed with fresh leaves of *Clinogyn dichotoma* (locally called “lamet”), placed inside a bamboo basket, and covered with a thick cloth. The covered basket is kept over the fireplace and fermented naturally for 3–5 days to obtain tungrymbai (Fig. 7). Tungrymbai is mashed and put into a container with water and boiled until the water evaporates with continuous stirring. It is mixed with fried onion, garlic, ginger, chili, ground black sesame (locally called “til”), and salt. A thick curry is made and is served as a side dish with steamed rice by Khasi in Meghalaya. Pickle is also made from tungrymbai. Khasi women are commonly seen selling tungrymbai packed in fresh leaves of “lamet” or banana at the vegetable markets of Shillong.
5.3. Functionality

Bacillus subtilis TS1:B25 (tungrymbai) and B. subtilis BT:B9 (bekang) accounted for the highest production of Poly-$\gamma$-glutamic acid (PGA) (2.8 mg/mL each) amongst the other strains tested [25]. Although lactic acid bacteria (LAB) showed antimicrobial activities, none of them produced bacteriocin and biogenic amines under the applied conditions. Enterococcus faecium TM2:L6 (tungrymbai) and BAV:E2 (bekang) showed the highest degree of hydrophobicity at 72.7% and 71.6%, respectively. LAB strains were able to degrade phytic acid and oligosaccharides, showing their ability to degrade antinutritive factors. Tungrymbai and bekang possess antioxidant and free radical (1,1-diphenyl-2-picryl hydrazyl (DPPH) and 2,2'-azino-bis (3-ethylbenzo-thiazoline-6-sulfonic acid) (ABTS)) scavenging activity [25].

5.4. Bekang

Bekang is an ethnic fermented soybean food commonly consumed by Mizo in Mizoram. It is also similar to kinema. During

- Soybean
  - Wash; boiled for 2-3 h
  - Loosely pack in a bamboo basket lined with leaves
  - Fermented (25-40°C, 2-3 d)
  - HAWAJAR

Fig. 5. Naturally fermented ethnic soybean foods of India.

Fig. 6. Traditional method of preparation of hawaijar in Manipur. Microorganisms: Bacillus subtilis (dominant functional bacterium), Bacillus licheniformis, Bacillus cereus, and other nonbacilli bacteria, e.g., Staphylococcus aureus, Staphylococcus sciuri, and Alkaligenes spp [2].

Fig. 7. Traditional method of tungrymbai preparation in Meghalaya. Microorganisms: on the basis of a combination of phenotypic and molecular characterization using ARDRA, ITS-PCR, and RAPD-PCR techniques, species of Bacillus isolated from tungrymbai were identified as Bacillus licheniformis (25.5%), Bacillus pumilus (19.5%), and Bacillus subtilis (55%) (dominant bacterium) [4]. ARDRA, The amplified amplification of polymorphic DNA; ITS-PCR, The amplification of 16S–23S rDNA intergenic transcribed spacer-Polymerase Chain Reaction; RAPD-PCR, Ribosomal DNA restriction analysis-polymerase chain reaction.
Bacillus licheniformis
subtilis
ampli
PCR, internal transcribed spacer-polymerase chain reaction; RAPD-PCR, random
ITS-PCR, and RAPD-PCR techniques, the species of
the basis of a combination of phenotypic and molecular characterization using ARDRA,

Bacillus subtilis

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Fig. 9. Traditional method of preparation of aakhone in Nagaland. Microorganisms:
Bacillus subtilis, and Proteus mirabilis [3].

the traditional method of preparation of bekang, small-sized, dry
seeds of soybean are collected, cleaned, and soaked in water for
10–12 hours. Excess water is removed and beans are boiled for 2–3
hours in an open cooker until the beans become soft. Excess water
is drained off and wrapped in fresh leaves of Calliparpa aroria
(Family: Verbanaceae), locally called “nulhinhan”, or in leaves of
Phrynium (Family: Verbanaceae), locally known as “hnahthial”.
The wrapped beans are kept inside a small bamboo basket. The
basket is then placed near the earthen oven or in a warm place and
is allowed to ferment naturally for 3–4 days. Sticky soybean with an
emission of ammonia odor is produced, which is liked by the local
consumers. The product is called bekang in Mizoram (Fig. 8).
Bekang is consumed as it is, or made into curry with the addition of salt,
green chillies, and tomatoes. It is consumed as a side dish with
steamed rice. Bekang is sold in the local markets by Mizo women,
who earn their livelihood this way [26].

5.5. Aakhone

Aakhone, also called axone, is an ethnic fermented sticky soy-
bean food of Sema Naga in Nagaland, similar to kinema. The prep-
aration is the same as for other fermented soybean foods of
north-east India. Soybean seeds are soaked, cooked, and the beans are

Soybean
Washed with water
Boiled for 1-2 h
Excess water drained off and cooled
Cooked soybean placed in container lined with banana leaves and covered loosely
Container kept near earthen-oven in kitchen
Fermented (20-35°C, 6-8 d)

AAKHONE

Fig. 8. Traditional method of preparation of aakhone in Nagaland. Microorganisms:
Bacillus subtilis, and Proteus mirabilis [3].

wrapped in fresh leaves of banana or Phrynium pubinerve Blume
(Family: Marantaceae) or Macaranga indica Wight (Family:
Euphorbiaceae), and kept above the fireplace to ferment for 5–7
days [27]. The shelf-life of freshly fermented aakhone is a maximum
of 1 week. Fresh aakhone is molded and made into cakes and dried
above the earthen oven. Sometimes, each fermented bean is
separated by hand and dried in the sun for 2–3 days. Dried aakhone
is stored in containers for future consumption (Fig. 9). Pickle is
made from freshly fermented aakhone by mixing with green chilli,
tomato, and salt. The dried aakhone cakes are cooked with pork and
are eaten as a side dish with steamed rice by Sema.

5.6. Peruyaan

Peruyaan is an ethnic fermented soybean food of Apatani tribes
in Arunachal Pradesh. The word peruyaan has been derived from
the Apatani dialect—perun means beans and yannii means packing
in leaves [26]. During the traditional preparation of peruyaan,
soybean seeds are collected, washed, and cooked for 2–3 hours
until the beans become soft. Excess water is drained off and is
cooled for some time. The cooked soybeans are kept in a bamboo
basket (vessel) lined with fresh ginger leaves, locally called “taki
yannii”. The basket is loosely covered with ginger leaves and is kept
on the wooden rack above the fireplace for fermentation for 3–5
days. The stickiness of the product is checked, and if the product is
considered sticky enough then it is ready for consumption (Fig. 10).
Peruyaan is consumed mostly as a side dish with steamed rice by
the Apatani tribes in Arunachal Pradesh. It is mixed with hot water,
chillies locally called “tero”, and salt, and directly consumed
without frying or cooking, unlike kinema curry preparation.

6. The similarity between kinema and other Asian nonsalted
Bacillus-fermented soybean foods

Kinema is similar to other Asian Bacillus-fermented sticky soy-
bean foods such as natto of Japan [28], chungkukjang of Korea [29],
and thua nabo of northern Thailand [30] (Fig. 11), pepok of northern
Myanmar [31], and sieng of Cambodia and Laos [32]. The prepara-
tion of kinema is very similar to that of natto. In itohiki-natto pro-
duction, whole soybeans are used for fermentation; in hikiwari-
natto production, dehulled soybeans are cracked into two to four
pieces and used [33]. Some of the steps in kinema preparation do
not resemble those in natto and chungkukjang, and thus make
kinema a unique nonsalted soybean-fermented product. The cooked
beans are lightly crushed to dehull most of the seeds.

Soybean
Soaked overnight
Boiled for 1-2 h
Dewatered, cooled down
Wrapped in leaves and placed inside basket
Basket kept in warm place
Fermented (20-35°C, 3-4 d)

BEKANG

Fig. 9. Traditional method of preparation of bekang in Mizoram. Microorganisms:
the basis of a combination of phenotypic and molecular characterization using ARDRA,
ITS-PCR, and RAPD-PCR techniques, the species of Bacillus isolated from bekang were
identified as Bacillus brevis (2%), Bacillus circulans (7.5%), Bacillus coagulans (6.5%),
Bacilluslicheniformis (16.5%), Bacillus pumilus (9.1%), Bacillus sphaericus (4.6%), Bacillus
subtilis (51.8%; dominant bacterium), and Lysinibacillus fusiformis (2%) [4]. ARDRA; ITS-
PCR, internal transcribed spacer-polymerase chain reaction; RAPD-PCR, random
amplified polymorphic DNA-polymerase chain reaction.

Soybean
Cleaned and washed with water
Cooked for 2-3 h
Excess water is drained off and cooled
Cooked soybeans packed in bamboo baskets lined with leaves of ginger
Kept on the wooden rack above the fire place
Fermented (20-35°C, 3-5 d)

PERUYAAN

Fig. 10. Traditional method of preparation of peruyaan in Arunachal Pradesh. Micro-
organisms: Bacillus subtilis, Bacillus amyloliquefaciens, Vagococcus lutere, Pediococcus
acidilactici, and Enterococcus faecalis [1].
However, fermentation is carried out with the kernels as well as the seed coats. Unlike natto and chungkukjang, kinema is always fried in oil and made into curry. The practice of frying kinema may have developed to drive out the unpleasant ammonia smell that masks the pleasant and persistent nutty flavor.

7. Phylogenetic similarity of Bacillus strains from Asian sticky fermented soybeans

The phylogenetic relationship among bacilli isolated from kinema (India), chungkukjang (Korea), and natto (Japan), similar fermented sticky soybean foods of Asia, on the basis of 16S rDNA sequences has been studied [34]. Strains of Bacillus isolated from kinema and chungkukjang show a central to paracentral position of spores with few strains showing negative nitrate reduction tests, whereas B. subtilis (natto) isolated from natto show a central position of spores and all reduce nitrate [34]. However, all strains of B. subtilis isolated from kinema, chungkukjang, and natto show stickiness on phytone agar and cooked soybean, which are characteristic properties of nonsalty fermented soybean foods of Asia [13]. However, the strain B. subtilis JCM 1465 does not produce any stickiness [34].

In order to investigate the phylogenetic relationship of isolates to other bacteria, the sequence of 16S rRNA gene polymerase chain reaction products was determined and it was found that strains B. subtilis KD:B1 and KC:B1 isolated from kinema, B. subtilis CA:B1 and CK:B2 isolated from chungkukjang, and B. subtilis JN-1 isolated from natto have identical sequences except that of JA-1 (natto), which has one ambiguous nucleotide [34]. The evolutionary distance between the four strains CK:B1, KD:B1, JN-1, and JA-1 and B. subtilis is 0.002 K\text{nuc} as calculated by the ratio of nucleotide substitution per nucleotide site, indicating 99% homology with the B. subtilis type strain. However, the evolutionary distance between the strains CA:B1 and KG:B1 and B. subtilis is 0.005 K\text{nuc}, showing approximately 99.5% homology with the type strain [34]. The phylogenetic analyses reveal that all six strains belonged to B. subtilis. This is the first report to describe the phylogeny of B. subtilis isolated from similar nonsalty fermented sticky soybean foods of Asia [34]. The plasmid of the B. subtilis (natto) strain resembles that of the B. subtilis strain in the partial nucleotide sequences [35–37]. The diversity of Bacillus subtilis-fermented soybean foods of Asia, including that of the Eastern Himalayas, needs to be studied in detail to determine the similarity. The probable source of a common stock of similar sticky fermented soybean foods will help food scientists to trace the antiquity of fermented soybean foods in Asia.

8. Kinema-natto-thua nao triangle hypothesis

Nonsalted fermented soybean foods are concentrated in a triangle with three vertices in Japan (natto), India and Nepal (kinema), and Indonesia (tempe). Nakao [38] named a “natto triangle” and
included both bacilli and mold-fermented soybean products, including tempe, and extended the triangle up to Indonesia. Tamang [1] renamed this hypothetical triangle the “kinema-natto-thua nao triangle” (KNT triangle) and included only nonsalty, Bacillus-fermented soybean foods with three vertices on India and Nepal (kinema and similar products), Thailand (thua-nao), and Japan (natto) (Fig. 12). Within the proposed triangle-bound countries, many fermented sticky nonsalty soybean foods are consumed by the different ethnic groups of people such as kinema (India, Nepal, and Bhutan), natto (Japan), tungrymbai, bekang, hawaijar, aakhone, and peruyaan (India), thua nao (Thailand), chungkokjang (Korea), pepok (Myanmar), and sieng (Cambodia and Laos). Beyond this hypothetical “KNT triangle”, there is no report of kinema-like products with sticky and ammonia-flavored fermented soybean foods and the proposed “KNT triangle” does not include salted, nonsticky, and nonbacilli fermented soybean products such as tempe, miso, sufu, soy sauce, etc. [1].

9. Discussion

It has been observed that flavorsome mucilaginous fermented soybean foods kinema, hawaijar, tungrymbai, bekang, aakhone, and peruyaan are popular among the Mongolian-origin races in the Eastern Himalayas. The Mongolian people prefer the umami-flavored foods due to specific sensory development. B. subtilis is the dominant functional bacterium in all fermented soybean foods of these regions. Fermented soybean foods are consumed only in the Eastern Himalayas; no such product is consumed in other parts of the Himalayas. Although there is good demand for ethnic fermented soybean foods among the local consumers in north-east India, the production is limited to household level. The scientific findings have correlated the indigenous knowledge of the ethnic people of the Himalayas and acknowledged the innovative skills of mountain women. Fermented soybean foods supplement the local diet with inexpensive, high-digested plant protein content and they have health-promoting properties.

References


Fig. 12. The kinema-natto-thua nao (KNT) triangle representing only Bacillus-fermented soybean foods of Asia [1].