

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(5): 499-503
www.biochemjournal.com
 Received: 21-03-2026
 Accepted: 26-04-2026

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Chhurpi: A traditional Himalayan fermented dairy product-production technology, nutritional composition, functional properties, and socio-cultural significance

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5f.8432>

Abstract

Chhurpi is a traditional fermented dairy product widely consumed in the Himalayan regions of India, Nepal, Bhutan, and Tibet. It is an important component of the indigenous food system and is recognized for its nutritional richness, long shelf life, and cultural significance. Chhurpi is generally prepared from yak, chauri, or cow milk through natural fermentation and is mainly categorized into soft and hard varieties based on processing methods and texture. Soft chhurpi possesses a soft and crumbly texture and is commonly utilized in soups, curries, and traditional dishes, whereas hard chhurpi undergoes extensive drying and develops a dense, compact structure with exceptional storage stability. The product is characterized by low moisture content, high protein concentration, moderate fat levels, and appreciable quantities of essential minerals such as calcium, phosphorus, potassium, and iron. These nutritional attributes make chhurpi a highly energy-dense food suitable for harsh high-altitude environments. The fermentation process, primarily mediated by lactic acid bacteria, enhances digestibility, improves sensory properties, and contributes to antimicrobial, immunomodulatory, and potential health-promoting effects through the formation of bioactive compounds. Chhurpi also plays a significant socio-economic role by supporting food security and livelihood generation among rural Himalayan communities. In recent years, the product has gained commercial importance as a natural chew product due to its hardness and nutritional composition. Overall, chhurpi represents a nutritionally valuable and culturally important fermented dairy product with promising potential in the development of functional foods and sustainable dairy-based enterprises.

Keywords: Chhurpi, fermented dairy product, Himalayan foods, lactic acid bacteria, traditional cheese, functional foods, nutritional composition, indigenous fermentation, yak milk, shelf stability

Introduction

Fermented foods have gained considerable scientific and societal interest due to their ability to enhance texture, flavor, nutritional composition, and shelf stability of food products. These improvements are primarily attributed to biochemical transformations mediated by microorganisms during fermentation (Rai *et al.*, 2016) ^[16]. Traditionally, fermented foods are closely linked to specific geographical regions and are developed using indigenous knowledge and locally available raw materials (Anal, 2019) ^[2]. In contemporary food processing, fermentation is carried out under controlled conditions using selected starter cultures to ensure consistent product quality, safety, and desirable functional attributes. Such processes contribute to improved organoleptic characteristics as well as nutritional and therapeutic benefits.

Among fermented foods, dairy-based fermented products are widely consumed across the globe due to their palatability and health-promoting properties. These products are known to exert several physiological benefits, including modulation of the immune system, inhibition of pathogenic microorganisms, potential anticarcinogenic effects, and reduction of serum cholesterol levels (García-Burgos *et al.*, 2020) ^[10]. In the Indian context, a substantial proportion of milk production is utilized for the preparation of traditional dairy products such as kheer, kulfi, khoa, and ghee.

Additionally, fermented milk products including dahi (curd), shrikhand, lassi, and chhach (buttermilk) constitute an integral part of the daily diet (Sarkar *et al.*, 2008) ^[19].

Fermented dairy products are also widely prevalent in the Himalayan regions, including Nepal, the Darjeeling Hills, Sikkim, Bhutan, Ladakh, and parts of Arunachal Pradesh. Ladakh, situated in the trans-Himalayan region of India, is characterized by a cold desert climate with low humidity, high solar radiation, and significant diurnal temperature variation (Panda *et al.*, 2016) ^[15]. These harsh environmental conditions limit agricultural productivity and livestock rearing, resulting in a diet largely dependent on cereals such as wheat and barley, dairy products, and limited quantities of meat. To address nutritional challenges, particularly the scarcity of fresh vegetables and protein-rich foods, local communities have developed a variety of traditional preservation techniques to ensure food availability during off-seasons (Wiley, 2004) ^[21].

Fermentation is one of the most extensively practiced preservation methods in this region, contributing to improved nutritional value, safety, and extended shelf life of food products (Bhatt *et al.*, 2015) ^[5]. Common indigenous fermented foods of Ladakh include tagikhambir, teemo, chhang, chhurpi, shyow, maar, kargyong, and satchu, which play a significant role in the local diet and cultural practices. The Himalayan region of India, extending from Jammu and Kashmir in the northwest to Arunachal Pradesh in the northeast, constitutes one of the most ecologically diverse and culturally rich zones in the country. This region encompasses a wide range of altitudes, climatic conditions, and agro-ecological systems, which have significantly influenced the dietary habits and traditional food processing practices of the local population. Due to geographical isolation, harsh climatic conditions, and limited agricultural productivity, the inhabitants of this region have developed unique food preservation techniques, among which fermentation plays a central role. Traditional fermented dairy products are particularly important, as they not only enhance the nutritional quality of milk but also improve its shelf life and safety under conditions where refrigeration facilities are often unavailable (Lukač-Havranek, 1991) ^[13].

The ethnic communities residing in the Himalayan belt have long relied on indigenous knowledge systems to produce a variety of naturally fermented artisanal dairy products. These products are valued for their enhanced digestibility, improved sensory attributes, and functional health benefits. Among these traditional dairy products, *chhurpi* holds significant importance as a highly nutritious, protein-rich fermented cheese (Goyal and Nanda, 2025) ^[12]. It is widely consumed in several parts of the eastern Himalayan region, including Sikkim, Darjeeling Hills, and Arunachal Pradesh, as well as in neighboring countries such as Nepal, Bhutan, and Tibet.

Chhurpi is distinguished by its characteristic smoky flavor, firm texture, and extended shelf life. One of its most notable features is its extremely hard consistency in certain forms, which has led to its popular description as “Himalayan chewing gum.” When chewed over time, the product gradually softens, making it suitable for prolonged consumption (Bora, 2023) ^[6]. This unique property has practical significance in high-altitude regions, where people often chew chhurpi during cold winter mornings. The act of chewing is believed to help maintain oral activity and

provide a sense of warmth, thereby aiding individuals in coping with extreme cold conditions.

Preparation of chhurpi

Traditionally, chhurpi is prepared from milk obtained from yak, chauri (a hybrid of male yak and female cow), or indigenous cattle, depending on the availability of livestock in a particular region. Yak milk, in particular, is highly preferred in high-altitude areas due to its higher fat and protein content, which contributes to the superior texture and nutritional quality of the final product. The choice of raw material plays a crucial role in determining the physicochemical and sensory characteristics of chhurpi.

Based on its method of preparation and textural properties, chhurpi is broadly classified into two main types: hard chhurpi and soft chhurpi. These two varieties differ significantly in terms of production process, composition, and utilization.

Soft chhurpi is generally produced from cow milk and is characterized by a soft, crumbly texture and mildly acidic flavor (Adhikari, 2024) ^[1]. The manufacturing process involves coagulation of milk proteins, followed by separation of whey. The resulting curd is collected, wrapped in a muslin or soft cloth, and hung at ambient temperature to facilitate further drainage of whey. During this stage, natural fermentation occurs, leading to the development of desirable flavor and texture. The final product is white to off-white in color and has a relatively high moisture content compared to its hard counterpart. In mountainous regions where fresh vegetables are scarce, soft chhurpi serves as an important dietary substitute. It is commonly incorporated into local dishes such as curries, soups, and pickles, thereby contributing significantly to protein intake and nutritional security.

In contrast, hard chhurpi, also referred to as *dudh chhurpi*, is primarily prepared from yak or chauri milk and undergoes a more extensive processing and drying procedure (Das, & Tamang, 2025) ^[9]. The production begins with the coagulation of milk, followed by cooking of the curd to achieve a firm consistency. The cooked curd is then subjected to pressing to remove excess moisture and is allowed to cure at room temperature for approximately two to three days. After curing, the solid mass is cut into uniform rectangular or cuboidal pieces. These pieces are subsequently dried either under direct sunlight or over a low-temperature wood fire for several days. The drying process significantly reduces the moisture content, resulting in a dense, compact structure with high hardness and chewiness.

The extremely low moisture content of hard chhurpi is a critical factor contributing to its exceptional shelf stability. When stored under appropriate conditions, such as in traditional containers made from yak skin, hard chhurpi can be preserved for several years, with some reports suggesting a storage life of up to two decades. This remarkable keeping quality makes it particularly valuable for nomadic herders and inhabitants of remote Himalayan regions, who often undertake long journeys and require durable, non-perishable food sources.

Hard chhurpi is typically marketed in the form of small, rectangular blocks with a hard and compact body. It is widely recognized as one of the hardest natural cheeses in the world. Despite its widespread consumption, considerable variation exists in the chemical composition, texture, and

sensory properties of chhurpi produced in different regions. These variations can be attributed to differences in milk source, microbial flora, processing techniques, and environmental conditions. Moreover, the preparation of chhurpi is deeply rooted in traditional knowledge systems and is often practiced at the household level, with methods being passed down through generations. As a result, regional and cultural diversity plays a significant role in shaping the unique characteristics of this traditional fermented dairy product.

According to the findings of Batra and Millner (1976), churpi contains only 2-4% moisture. This very low moisture content is one of the major characteristics of the product and is responsible for its hard texture and excellent storage stability. Since water activity is very low, microbial growth and spoilage are minimized, allowing churpi to be stored for long periods without refrigeration. The drying process also concentrates nutrients such as protein, fat, and minerals.

Further studies by Katiyar *et al.* (1991) reported the average chemical composition of churpi per 100 g as moisture 3.9-4.2 g, ash 6.6-7.2 g, protein 53.4-57.6 g, carbohydrate 20.4-23.2 g, and fat 11.2-12.3 g. The exceptionally high protein content indicates that churpi is a highly concentrated source of milk proteins, mainly casein. Such a high level of protein contributes to its nutritional significance, especially in mountainous regions where protein-rich foods are limited. Protein also plays an important role in body growth, tissue repair, and maintenance of muscle mass.

The fat content of 11.2-12.3 g per 100 g contributes to the energy density and flavor of the product. Milk fat supplies essential fatty acids and fat-soluble vitamins while also improving mouthfeel and palatability. Compared to many other dairy products, the moderate fat content of churpi provides a balanced source of energy without excessive lipid levels.

Carbohydrates in churpi range from 20.4-23.2 g per 100 g. These carbohydrates mainly originate from residual lactose and products formed during fermentation. During the manufacturing process, lactose is partially fermented by lactic acid bacteria, improving digestibility and contributing to the characteristic flavor of the product.

The ash content (6.6-7.2 g) indicates that churpi is rich in minerals. Mineral analysis showed the presence of phosphorus (733 mg), potassium (168-176 mg), sodium (104-106 mg), calcium (70-76 mg), and iron (2 mg). Phosphorus and calcium are essential for bone and teeth development, while potassium and sodium help maintain electrolyte balance and nerve function. Iron contributes to hemoglobin formation and prevention of anemia.

The metabolizable energy value of 407-411 kcal per 100 g demonstrates that churpi is a highly energy-dense food. This high caloric value makes it particularly suitable for people living in cold mountainous regions, where energy requirements are greater due to harsh climatic conditions and physical activity.

Numerous scientific studies have demonstrated that fermented milk products possess a wide range of health-promoting properties, primarily attributed to the metabolic activities of beneficial microorganisms involved in fermentation. These functional attributes include antimicrobial activity, immunomodulatory effects, anticarcinogenic potential, and the ability to reduce serum cholesterol levels. Such effects are largely associated with the production of organic acids, bacteriocins, and bioactive

compounds during fermentation, which collectively contribute to improved gut health and overall physiological well-being.

Traditional fermented dairy products, such as chhurpi, play a significant role not only in enhancing nutritional security but also in supporting the socio-economic conditions of rural and high-altitude communities where they are produced and consumed. In these regions, chhurpi serves as both a staple dietary component and a source of livelihood, contributing to income generation through local trade and small-scale commercialization (Sapkota, & Khatiwada, 2024) ^[18].

From a nutritional perspective, chhurpi is considered a highly valuable dairy product due to its favorable composition. It is typically characterized by a relatively low fat content and a high protein concentration, making it suitable for individuals seeking to manage metabolic disorders such as diabetes or those aiming to support muscle growth and repair. The high protein content also enhances satiety and contributes to improved nutritional status in resource-limited settings. In addition, chhurpi contains appreciable levels of essential vitamins, particularly vitamin A, which plays a critical role in vision, immune function, and cellular growth (Goyal & Nanda, 2025) ^[12].

Furthermore, chhurpi is reported to possess a comparatively higher concentration of essential amino acids than conventional cheeses produced from cow milk, thereby improving its biological value as a protein source. It is also rich in important minerals such as calcium, phosphorus, magnesium, and zinc, which are essential for bone health, enzymatic functions, and metabolic regulation. The presence of omega-3 fatty acids and naturally occurring antioxidants further enhances its functional profile by contributing to cardiovascular health and reducing oxidative stress (Oppedisano *et al.*, 2020) ^[14].

An important aspect of chhurpi production is its organic nature. The milk used for its preparation is often obtained from yaks or chauri that graze freely on natural alpine pastures rich in diverse herbs and grasses. This feeding system not only influences the nutritional quality of the milk but also contributes to the presence of beneficial phytochemicals in the final product. Moreover, the traditional methods employed in chhurpi production are largely free from synthetic additives, preservatives, or chemical interventions, thereby ensuring a clean-label and minimally processed food product (Chauhan & Rao, 2024) ^[7].

The fermentation process of chhurpi is predominantly driven by lactic acid bacteria (LAB), which play a crucial role in determining both the safety and functionality of the product. These microorganisms facilitate the conversion of lactose into lactic acid, leading to a reduction in pH that inhibits the growth of spoilage and pathogenic microbes. In addition, LAB are known to produce bioactive peptides during proteolysis, which exhibit various physiological benefits, including antihypertensive, antimicrobial, and immunomodulatory activities. The metabolic by-products of LAB also contribute to the development of characteristic flavor, aroma, and texture of chhurpi (Chourasia *et al.*, 2024) ^[8].

In the case of hard chhurpi, its dense texture offers additional functional benefits related to oral health (Gautam *et al.*, 2025) ^[11]. Prolonged chewing of hard chhurpi can aid in mechanical cleaning of teeth, thereby helping in the

reduction of dental plaque and tartar accumulation. This chewing action may also stimulate salivary flow, which is beneficial for maintaining oral hygiene and strengthening gum tissues

Chhurpi is one of the most widely consumed traditional fermented milk products in the Himalayan regions, including Darjeeling Hills, Sikkim, Nepal, Bhutan, and parts of Arunachal Pradesh. It holds significant cultural and dietary importance among the local populations, where it is incorporated into daily meals in various forms. Consumption patterns indicate that chhurpi contributes meaningfully to the diet, with reported average per capita intakes of approximately 6.9 g/day in the Darjeeling Hills and around 9.9 g/day in Sikkim (Tamang *et al.*, 2007) ^[20]. These values reflect its role as a supplementary yet nutritionally important food component in these regions.

The culinary applications of chhurpi vary depending on its form, primarily categorized as soft and hard chhurpi, each having distinct uses and functional attributes. Soft chhurpi, owing to its high moisture content and relatively short shelf life, is generally consumed soon after preparation. It is characterized by a soft, crumbly texture and a flavor profile that can range from mild to moderately strong, depending on the extent of fermentation. In traditional cuisine, soft chhurpi is extensively utilized as an ingredient in a variety of dishes. It is commonly used as a filling material in steamed products such as momos, where it contributes to both flavor and nutritional value. Additionally, it is incorporated into soups, providing a rich and creamy consistency along with enhanced protein content.

Beyond these applications, soft chhurpi is frequently used in the preparation of vegetable-based dishes, curries, and pickles (Roopashri *et al.*, 2023) ^[17]. In regions where the availability of fresh vegetables is limited due to climatic constraints, it often serves as a valuable substitute, enriching meals with essential nutrients. It is typically consumed alongside staple foods such as boiled rice, forming a balanced and satisfying meal. Its adaptability in different culinary preparations highlights its importance as a versatile ingredient in traditional Himalayan diets.

In contrast, hard chhurpi exhibits entirely different culinary and functional characteristics due to its extremely low moisture content and dense, compact structure (Bhat *et al.*, 2022) ^[4]. It is primarily consumed as a snack rather than as a cooking ingredient. Owing to its hardness, it is chewed over an extended period, gradually softening in the mouth, which provides a sustained release of energy. This makes it particularly suitable for individuals engaged in physically demanding activities, such as herders and laborers in high-altitude regions.

In addition to human consumption, hard chhurpi has also gained recognition as a natural and nutritious product for animal use, particularly as a chewable treat for dogs. Its high protein content, along with the presence of essential nutrients, makes it a healthier alternative to synthetic pet snacks. Furthermore, its hard texture promotes dental health in animals by aiding in the mechanical removal of plaque.

Conclusion

Chhurpi is a nutritionally rich and culturally significant traditional fermented dairy product of the Himalayan region that reflects the indigenous knowledge and food preservation practices of local communities. Its unique production process, involving natural fermentation and

extensive drying, contributes to its characteristic texture, prolonged shelf life, and enhanced nutritional quality. The product is an excellent source of protein, essential minerals, and energy, making it particularly suitable for high-altitude populations living under harsh climatic conditions. Fermentation by lactic acid bacteria improves digestibility, sensory properties, safety, and potential health benefits through the formation of bioactive compounds. In addition to its dietary importance, chhurpi contributes to food security, rural livelihoods, and the preservation of traditional food heritage. The growing interest in natural and functional foods further highlights its potential for commercialization and wider utilization. However, further scientific studies are needed to standardize processing methods, explore microbial diversity, and validate its functional and therapeutic properties while maintaining its traditional authenticity.

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