A comprehensive study on the traditional fermentation practices and contemporary perspectives of *Mishti doi* in Bengal

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Short Report

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Abstract

This study aims to document a popular traditional fermented milk product, *Mishti doi*, from North Bengal, India. *Mishti doi* is a popular regional delicacy known for its sweet, caramelised flavour, thick and creamy consistency. The consumption of *Mishti doi* in Bengali culture is deeply rooted in tradition, with applications ranging from everyday meals to religious rituals and modern culinary innovations. This study looks at the cultural significance, traditional preparation methods, and the role of local dairy practices. Through interactions with traditional sweet makers, the documentation highlights the craftsmanship involved in making *Mishti doi*, demonstrating the techniques passed down through generations. It also discusses the difficulties of preserving authenticity in the face of industrialisation and commercialisation. Additionally, the survey analyses the influence of modern food trends on this age-old delicacy. The findings contribute to the preservation and promotion of *Mishti doi* as an integral part of Bengal's cultural heritage while exploring opportunities for its broader market potential.

Introduction

The West Bengal state is a part of eastern India that shares an international border with Bangladesh as well as Nepal and Bhutan. It extends from the Himalayas in the north to the Bay of Bengal in the south. West Bengal is surrounded by Assam and Sikkim in north east, Orissa in the southwest, and Jharkhand and Bihar in the west. The state's precise coordinates are 27°13'15" and 21°25'24" north latitudes, and 85°48'20" and 89°53'04" east longitudes [1]. The Ganga river has traditionally divided Bengal into South Bengal and North Bengal, which are further divided into Terai and Dooars regions. The northern part of West Bengal is known as North Bengal. It is the west of the Jamuna river and north of the Padma river, which includes the Barind Tract. The North Bengal section includes the Jalpaiguri division (Alipurduar, Cooch Behar, Darjeeling, Jalpaiguri, and Kalimpong) as well as the Malda division (Uttar Dinajpur, Dakshin Dinajpur, and Malda) [2] (Fig. 1). West Bengal is known for its rich biodiversity, featuring a wide variety of flora and fauna due to its climatic variations. Bengal has a diverse population, including Bengalis, tribal groups, and smaller ethnic minorities. The Bengali community represents the largest population group, while tribal communities such as the Santhal, Munda, Oraon, Koch-Rajbongshi, and Toto also form an integral part of the state's demographic composition. Different food products are also available due to differences in culture, geographical indication, and raw material availability (grains, milk, plant sources) [3]. West Bengal is renowned for its rich and diverse culinary heritage, where traditional dishes featuring fish, rice, and an array of sweets hold a prominent place. A variety of fermented foods are also produced, which can be divided into four classes (cereal- and pulse-based, plant-based, dairy-based and fish-based) [4]. Among of them fermented milk products are most common. Local people prepare traditional fermented foods by using ancestral ethnic knowledge. Some examples of naturally fermented milk products include *lassi*, *mishti dahi*, *rabri*, *shrikhand*, *chhu* and *chhurpi* [5]. Among them *Mishti doi* is one of the popular dessert throughout the Bengal. This study aims to the production technology of ethnic people, cultural significance and also identifying the gaps in research and suggesting potential areas for future exploration.

Methodology

The survey was done by open questions and face-to-face interviews as the primary method of qualitative data collection. The study area, referred as North Bengal, located in the northern part of West Bengal. The North Bengal section includes the Jalpaiguri division (Alipurduar, Cooch Behar, Darjeeling, Jalpaiguri, and Kalimpong) as well as the Malda division (Uttar Dinajpur, Dakshin Dinajpur, and Malda). Information gathered from local residents during the survey is crucial for preserving traditional knowledge related to *Mishti doi* production. Samples of fermented milk product (*Mishti doi*) was collected aseptically in sterile sample bottle from the different part of North Bengal and kept in ice box carrier and transported to laboratory and stored at -20^0 C for further analysis. In addition to the survey, a thorough analysis of literature was conducted, gathering critical information from various sources, such as books, journal articles, and other published materials. Sources were collected from academic databases which are commonly used for research, including Google Scholar, Web of Science, Springer, ScienceDirect, and Scopus. The review focused on publications from 1990 to 2024, with the scholarly papers analysed using a mix of qualitative and quantitative methodologies.

Data were collected on the housing and feeding systems in dairy farming, including the location of animal shelters and patterns of feeding and grazing. Information on farmers' demographic characteristics—such as caste, gender, education level, occupation, and annual income—was also gathered. A significant portion of West Bengal's rural population depends on agriculture and related sectors like animal husbandry for their sustenance. This sector provides crucial income and employment opportunities for small-scale farmers, landless workers, and women. Additionally, it plays an essential role in improving food availability and nutritional well-being through the production of dairy, meat, and eggs. Animal husbandry and dairy farming have played a crucial role in human society since ancient times. Both cooperatives and private dairy enterprises contribute significantly to this production. The livestock sector constitutes a vital part of the agricultural economy. Livestock production and crop farming are deeply interconnected, each contributing essential resources to the other. This integration supports key livelihood activities, enhances household nutrition and health, and provides additional income and employment opportunities. In rural areas of West Bengal, two primary grazing systems were identified: controlled grazing and free (or uncontrolled) grazing. Agricultural land is commonly used for grazing. Additionally, animals are often tethered along riverbanks, near ponds and canals, beside roads, and in open fields. Uncontrolled grazing practices were closely linked to the types of crops grown and the cropping intensity in a given area. In the absence of free grazing land, villagers resorted to using crops like vegetables, oilseeds, paddy, and pulses as livestock feed. An analysis of feed selection revealed that the preference for certain feed types varied across livestock species and was strongly influenced by their species-specific characteristics. Common indigenous breeds include Sahiwal, Jersey crossbreeds, and Holstein Friesian crossbreeds. The state annually produces more than 6 million tonnes of milk according to recent data. Women in farming households played a key role in managing dairy activities. They were primarily responsible for tasks such as cleaning animal shelters and feeding the livestock. Men generally took charge of decisions related to purchasing and selling animals, as well as

transporting milk to sweet shops, markets, and homes. Milk was collected from farms and delivered to local collection points, often managed by village communities or cooperatives. Here, milk was weighed and its quality was tested. Based on both quantity and quality, farmers receive their payments. After collection, the milk is transported to processing plants where it undergoes pasteurization to ensure safety and homogenization for consistency and distributed to nearby sweet makers or wholesalers. Large-scale sweet manufacturers often purchase dairy supplies directly from cooperatives or processing units to ensure reliable quality and supply. Milk was turned into other dairy products such as *ghee*, *paneer*, *khoya*, or *chhena*. Using these ingredients, sweet makers craft traditional Bengali delicacies like *rasgulla*, *sandesh*, *chamcham* and different fermented milk product like *mishti doi*, *rabri*, *lassi* etc. Ethnic peoples using unique techniques for preparing these fermented milk product and it remain unchanged despite advancements in Indian cuisine. The preparation of these products is unique to Bengali community and cannot be found anywhere else. Local people using cow or buffalo milk for preparation of *Mishti doi.*Ethnic people used trial and error approaches to improve food quality. Indigenous knowledge is passed down and modernised with each generation. Eventually, the finished sweets are sold in sweet shops, local marketplaces, and increasingly through online platforms. They are especially popular during cultural celebrations, festivals, and are also exported. People in West Bengal region regularly consume *dahi* and it is traditionally offered to God during worship. The product's approximate selling price is Rs. 150–250 per kg.

Traditional milk products of India

People use milk as part of regular diet in India, where the majority of citizens are vegan. Cattle were an important part of Vedic traditions prior to 800 BCE. Literature refers that, milk (cow, buffalo, and goat) was consumed in raw form [6]. One of the simplest technique for protecting milk nutrients and increase the products shelf life for human consumption is fermentation. The majority of natural milk products are fermented either spontaneously or by the back-sloping method. Back-slopping involves inoculating a fresh batch of a fermented product with a portion of a previous batch of the fermented food. Fermentation is an enzyme catalysed, metabolic process, where micro-organisms convert the complex carbohydrate molecules to smaller components like alcohol and acid anaerobically. The process of fermentation not only expands the product's life span but also enhances flavour and makes milk easier to digest. The most widely consumed and ancient type of fermented milk in India, is *dahi* that produced and consumed in every family [3]. Indian fermented milk products are distinctive because of dynamic sociocultural practises that have evolved over several years. Some of the naturally fermented milk products of India include *lassi, mishti dahi, rabri, shrikhand, chhu and chhurpi*, [5, 7].These products enormous microbial diversity and distinctive metabolic footprints match their regionally specialised technological, economic, and sensory characteristics [8].

History of Mishti doi

Mishti doi is a common fermented milk product which is very well in eastern India, particularly in West Bengal, Bihar, and Assam. *Mishti doi i*s originated in the Bogra district of Bangladesh. Regardless of cast,

creed or culture *Mishti doi*, is an essential part of every Bengali's kitchen. Indo-Aryan ethnoliguistic group are known as bangalees or Bengalis and they are historically connected to the Bengal region of South Asia. They belong to the eastern group of Indo-Aryan languages and correspond to the Magadhan subfamily [9]. In both rural and urban Bengal, *Mishti doi* is regarded as a special dessert for ceremonial events. The typical brown hue, firm texture, creaminess, and caramelised flavour of good *Mishti doi* are all there. [9]. It is currently commercially made and distributed throughout the nation Fig. 3. The product is commonly sold in various-sized earthen pots. *Streptococcus salivarius subsp. thermophilus*, *Lactobacillus acidophilus, Lb. delbrueckii subsp. Bulgaricus* and *Lactococcus lactis subsp. lactis* are the predominant microbes found in *Mishti doi* [10, 11, 12, 13]. These microorganism ferment lactose into lactic acid. This acid contributes to the overall flavour of the product and subsequently improves preservation and also developed its unique distinctive body texture. *Enterococcus italicus*, *Lactobacillus helveticus*, *Lactococcus raffinolactis*, *Bifidobacterium mongoliense*, *Hafnia alvei*, *Lactococcus lactis*, *Acetobacter okinawensis*, *Streptococcus thermophilus*, *Thermus thermophilus*, *Leuconostoc citreum*, *Leuconostoc pseudomesenteroides*, *Acetobacter orientalis*, *Lactobacillus gallinarum*, *Lactococcus chungangensis* are the predominant bacteria found in *Mishti doi* as per the metagenomics study [14].

Socio-cultural significance of Mishti doi:

Dessert: *Mishti doi* is primarily consumed as a dessert in Bengal and the surrounding regions. It is a popular sweet treat, often served at the end of meals or on special occasions such as festivals and celebrations. Its rich, sweet, and slightly tangy flavor makes it a satisfying end to any meal. Traditionally served in a small clay pots, it offers a unique texture and taste experience that combines creamy smoothness with a hint of caramel. *Mishti doi* is sometimes paired with other sweets like *rasgulla* or garnished with some dry fruits. Its versatility has also inspired modern dessert innovations, such as *mishti doi* mousse, parfaits and fusion ice creams, allowing this traditional treat to find a place in contemporary menus as well.

Religious Offerings and Festive Gift: *Mishti doi* is more than just a dessert in Bengali culture it carries religious and spiritual meaning. It is often used as an offering in Hindu rituals and prayers, symbolizing purity, devotion, and good fortune. Made with milk and jaggery, ingredients considered sacred. *Mishti* doi is commonly presented to deities during pujas and festivals like Durga Puja, Lakshmi Puja, and Saraswati Puja. This product has been regarded sacred and is linked to traditional rituals such as marriage ceremonies, puja (worship), *Ashirbad* (blessings), *Upanayana*, and *Annaprasan* (the first rice-eating ceremony), where it is served as a sign of blessings and prosperity. The use of earthen pots to set *mishti doi* adds to its spiritual essence, reflecting simplicity and a deep connection to nature and tradition. *Mishti doi* is a traditional Bengali gift given during festivals, family gatherings, and visits to relatives which signifies prosperity and happiness.

Culinary Ingredient: *Mishti doi* is an ingredient used in a variety of Bengali sweets and fusion desserts, including cakes, shakes (*doi-er-ghol*), and ice cream. Its thick, creamy texture and caramelised flavour make it an ideal base for innovative dessert recipes. Combining *mishti doi* with cake is a delightful

fusion and it is a delicious way to blend classic Bengali flavors with a modern dessert format. This *Mishti Doi* Cake recipe yields a soft, moist treat, rich with the distinct caramel-like essence. *Doi-er-ghol* is a traditional Bengali yogurt-based drink that's refreshing, light, and perfect for hot days. It's similar to lassi but typically more diluted and can be made sweet or salty. For making *doi er ghol*, yogurt is blended until it becomes smooth and creamy, without lumps. Gradually cold water is added to get a thin, frothy, drinkable consistency not as thick as a *lassi*. For sweet *ghol* sugar and cardamom powder was added and for salty *ghol* salt and a pinch of roasted cumin powder was added. *Mishti do*i Ice cream fusion, blends the sweet, slightly tangy flavor of traditional mishti doi with the smooth, creamy texture of ice cream. *Mishti doi* is a popular Bengali dessert made by boiling full-fat milk, adding sweetness (usually with date palm jaggery or sugar), and letting it ferment with live cultures in clay pots. This process creates a thick, creamy yogurt with a caramel-like flavor and aroma. Ice cream, made from milk, cream, sugar, and stabilizers, is a perfect base for mixing in local and traditional tastes. Its rich, smooth texture allows it an excellent match for *mishti doi.*

Mishti doi are produced in different part of West Bengal and production are varies greatly depending upon the local community and also different name was given by the local people. These are *Lal doi*, *Jhuri pata doi* and *Khir doi* [10, 11] Fig. 2 and Fig. 4.

Lal doi

Lal doi was originated from Nabadwip (23.4037°N, 88.3659°E), located in the Nadia district of West Bengal. According to the book "Chaitanya Charitamrita," Sri Chaitanya Mahaprabhu loved this sweet. On Gaura Purnima, the birth anniversary of Sri Chaitanya Mahaprabhu (18 February 1486), Vaishnava worshippers fast all day till moonrise then eat "*Lal doi*" as an un-editable part of their meal [15]. It is also known as "*chakku doi*". Chakku means knife and the stickiness of *doi* is measured by inserting a knife (chakku) into the sweet so it is named as *chakku doi.*The basic ingredients are whole milk and sugar (4:3 v/v ratio). Local people used cow or buffalo milk for making this *doi.*The milk was simmered gently for 7 to 8 hours until its volume was reduced to one-third, developing a rich reddish hue (known as *lal*) from the prolonged cooking. With constant stirring, jaggery was added gradually to enhance the flavour. Once the desired sweetness was achieved, the mixture was allowed to cool to room temperature. A small amount of previously prepared *lal doi* (fermented curd) was added as a starter culture. The mixture was then carefully poured into traditional earthen pots (*matir bhar*) and placed near burning charcoal embers, covered with jute sacks to retain warmth. This environment allowed the curd to set naturally over 2 to 3 days. Various sized of earthen pot were (*matir bhar*), chosen to meet market demand.

Kheer doi

Gangarampur is situated in the Dakshin Dinajpur district of West Bengal (25.4009°N, 88.5324°E). Gangarampur is popular for *kheer* based dairy product. *Kheer*, is a popular South Asian dessert, has a rich and ancient history dating back more than 2,000 years. It was first mentioned in Ayurvedic texts and temple records of ancient India [16]. *Kheer* is usually made by boiling milk for prolonged time with sugar or jiggery. The slow cooking process helps the milk reduce to give thick and creamy texture. *Kheer*

influenced similar dishes in Central Asia, the Middle East, and Southeast Asia, including *firni*, *rice pudding*, and *payesh*. Despite its numerous regional variations, *kheer* is still a beloved part of festivals and everyday meals, and it is one of the oldest and most enduring desserts in Indian cuisine. *Kheer* is usually made by boiling milk, sugar, or jiggery. Often flavoured with aromatic spices like cardamom and saffron, and garnished with nuts like almonds and cashews. In Gangarampur *kheer Doi*, is a type of traditional sweetened curd. The main ingredients are cow's milk and sugar. Milk was heated until "*Kheer*" has been reached.Then the caramelised sugar was mixed with "*kheer*" and previously prepared *dahi* was introduced to it. The bowl was kept in a warm environment for 8–10 hours. Final product was refrigerated for 2–3 hours to achieve the desired texture.

Jhuri pata doi

It is a special kind of sweetened *dahi* that originated and found in Murshidabad (24.1759°N and 88.2802°E) district of West Bengal. Murshid Quli Khan (1717–27), the Diwan (chief revenue officer) of Bengal, under Aurangzeb, was fond of this sweet [15]. Usually, *dahi* is settled in earthen pots, but in this case, "*jhuri*" (bamboo basket) is used, so it is named as *Jhuri pata doi.*Milk was heated for 1–2 hours and then caramelised sugar was mixed with it. Inside this "*jhuri*", dried and condensed milk was used to seal the wholes of the basket. After coating of the basket, milk was poured to the *jhuri* and previously prepared *doi* was added for curding. The curd is thicker and yellowish in colour. It is less sweet than the other sweetened dahi.

Nutritional property of Mishti doi

Milk is a rich source of essential nutrients such as calcium, protein, vitamin D, phosphorus, riboflavin and vitamin A. It also contains important minerals like magnesium, zinc and iodine. Fermentation of milk leads to a number of organoleptic and nutritional changes, which are greatly influenced by the metabolic activity of starter cultures. *Dahi*, a popular traditional fermented milk product in India, differs significantly from its commercial counterparts due to variations in household production practices and the use of undefined microbial consortia as inoculants. Furthermore, the nutritional and technological value of traditional fermented milk products is influenced by a number of factors, including the composition of the milk, the microbial consortia present in the inoculum, and the unique methods of processing [18, 19, 20]. During the preparation of *Dahi*, jaggery was used as sweetener and flavouring agent. Jaggery offers a better nutritional profile than the refined sugar due to its natural processing method. It is a good source of minerals like iron, calcium and magnesium. Proteins and carbohydrates undergo biotransformation through the milk fermentation process, by microorganisms or enzymes produced by them. Furthermore, indigenous enzymes contribute in the hydrolysis of milk protein and carbohydrate sources, which is responsible for the texture and flavour variations observed in the finished product. Differences in protein and carbohydrate content cause variations in body and texture scores among *dahi*. Nutritional values of *Mishti doi* mentioned in Table 1. If the total solids content of a milk sample is low, the texture of *dahi* will be similarly low. The addition of fruit juice, date palm, and sugar to *dahi* or yoghurt improved its consistency [21].

Table 1
Nutritional value of *Mishti doi*

Titratable acidity (%)	Total solid content (%)	Fat content (%)	protein content (%)	Carbohydrate content (%)	Ash content (%)	References
0.36 to 1.17	271.27 to 280.03	47.3 to 49.67	7.1 to 7.5	5.7 to 10.5	7.1 to 7.5	[21]
0.7 to 0.80	17.11 to 21.80	4.88	3.99 to 4.74	8.47	0.7 to 0.9	[22]
0.56 to 0.64	-	-	2.98 to 3.13	5.82 to 11.85	5.82 to 9.50	[23]

Health benefits of dahi

Dahi is well-known for its health benefits (Fig. 5). Being a fermented dairy product, *Mishti doi* contains probiotics that contribute to gut health. Fermented foods have been associated with improved digestion and overall wellness. "*Doi*" contains high levels of calcium (83 mg/100 g) and phosphorus (38 mg/100 g), which prevents arthritis and strengthens teeth and bones. These foods reduce cortisol secretion (an imbalanced cortisol level causes more fat accumulation in the body) and aid in weight loss. As a probiotic food (rich in *Lactobacillus* and *Leuconostoc sp.*), it boosts immunity and aids the proper functioning of the digestive system [16]. The scientific community's interest in studying the therapeutic properties of food products was influenced by Ellie Metchnikoff's seminal finding linking about consumption of traditional fermented milk products linking to the longevity of Bulgarian peoples [24]. The use of fermented dairy products like *dahi* in traditional ayurvedic formulations, such as *Panchgavya* dating back to 600 AD, reinforces their status as functional foods. *Dahi* is recommended for preventing digestive disorders including constipation, diarrhoea and dysentery and for limiting the growth of intestinal bacteria. *Dahi* has also been reported to reduce blood cholesterol levels. Metagenomic and metagenome-assembled genome (MAG) tools are used to identify biomarkers for genes responsible for various health-promoting functions present in *Mishti doi.*All MAGs (Metagenome-Assembled Genomes) exhibited a range of genes with potential roles in various functions, including probiotic and prebiotic activities, short-chain fatty acid production, immune system modulation, antitumor effects, and the synthesis of essential amino acids and vitamins [14].

Different types of *dahi* are often made using a mixed culture of *Streptococcus lactis*, *Streptococcus thermophilus, Lactobacillus bulgaricus, and Lactobacillus plantarum*. Together with culture, 10 to 12% sugar is added for making sweet *dahi* [25]. Considering the existing reports on several health-promoting properties as well as their generally recognized as safe (GRAS) status of LAB, they can be widely used in the developing of new fermented milk products. *Lactococcus lactis lactis*, *Lactococcus lactis sp. Cremoris*, *Lactobacillus kefir*, *Lactobacillus kefiranofaciens*, *Lb. acidophilus*, *S. thermophilus*, *Lb. delbrueckii ssp. Bulgaricus*, *Lactobacillus delbrueckii ssp. lactis*, *Lb. helveticus*, *Lb. casei*, are the functional dairy starter cultures [26].

The metabolic process of various beneficial microbes, particularly the LAB, has a direct impact upon the alterations in biochemical components in the milk leads to changing the rheological and functional properties, resulting nutritional enhancement of the final product. LAB produces metabolites include bacteriocins, enzymes, organic acids, gases, hydrogen peroxide, vitamins, exopolysaccharides, diacetyl, acetoin, and acetaldehyde, low molecular weight compounds such as reuterin and phenyl lactic acid, antifungal metabolites (cyclic dipeptides and phenyllactic acid), proteinaceous compounds, 3-hydroxylated fatty acid, and so on [8]. Scientific and industrial interests in creating foodstuffs in addition to delivering nutritional value, can also improve the consumer's general health [27, 28]. So probiotic dairy products are therefore of great interest to both consumers and researchers who are looking for nutritious foods with enhanced health advantages such as enhancing the bioavailability of vitamins and minerals, protecting against infectious agents, immunomodulatory effects, anti-allergenic effects, anti-obesity effects, and anti-anxiety effects, decrease the symptoms of lactose intolerance, among others [29, 30, 31, 32]. Probiotic is the live microorganisms that can confer at least one health benefit when given in sufficient amount to host. Probiotics have grown in significance in both basic and applied research and also a valuable economic topic of interest as a result of their rising popularity [33]. *Bifidobacterium* (*adolescentis, casei, fermeanimalis, bifidum, breve, and longum*) and *Lactobacillus* (*acidophilus, casei, fermentum, gasseri, johnsonii, paracasei, plantarum, rhamnosus, and salivarius*) was well-studied species, that "promotes a healthy gut flora" and having general health advantages notably for the gastrointestinal tract and immune function [34, 35]. Consuming probiotics can promote intestinal health by regulating the microbiota, stimulate the immune system's growth and function, increase the bioavailability of nutrients, and lower the chance of developing a number of diseases [36] mentioned in Table 2. LAB-driven fermentations frequently produce by-products that are bioactive and have a variety of health-promoting effects.

Table 2
Functional properties of Dahi:

Health benefits	Name of the Bacteria	Method of analysis	References
Inhibitory activity against *P. aeruginosa* and *S. aureus*	*Lactiplantibacillus plantarum* ADMH 97 *Lactiplantibacillus* *pentosus* ADMH 73 *Lacticasebacillus rhamnosus* ADMH 2 *Lactobacillus pontis* ADMT 16 *L. plantarum* ADMG 1	*in-vitro*	[37]
The DPPH radical scavenging activity (with percentage of 75% and 44.85%).	*L. plantarum* ADMH 97 *L. plantarum* ADMG	*in-vitro*	[37]
Serum pro-inflammatory (TNFα, IFNγ), and anti-inflammatory (IL-10) cytokine levels were increased. Lymphocyte counts were increase from 3707 ± 1551 to 6312 ± 1937 after 6 weeks of treatment.	*Lactobacillus bulgaricus* and *Streptococcus thermophiles*	Clinical trial (children patients suffering from protein energy malnutrition)	[38]
Free amino acids and γ-Aminobutyric acid (GABA), polyphenols availability, antioxidant activity (up to 54%)	*L. rhamnosus* SP1, *W. confusa* DSM 20194, *L. plantarum* T6B10	*in-vitro*	[39]
[alpha]- amylase inhibitory activity associated with the management of postprandial hyperglycemia	*Lactobacillus (Lb.) plantarum*	*in-vitro*	[40]
Cholesterol-lowering activity, EPS production, antioxidant property	*L. acidophilus* (WFA1, WFA2, and WFA3)	*in-vitro*	[41]
EPS production, antibacterial activity against pathogenic strains *E. coli* ATCC25922, *S. aureus* ATCC6538, *P. aeruginosa* ATCC25923, and *L. monocytogenes*	*S. thermophiles*	*in-vitro*	[42]
Increasing immune cell levels in malnourished children, especially in the age group of 7–8. Monocytes (3.11 to 5.21), neutrophils (26 to 38), basophils (0.72 to 0.84), and lymphocytes (27 to 35)	*Lactobacillus acidophilus*, LBKV-3	Clinical trial	[43]

Health benefits	Name of the Bacteria	Method of analysis	References
Reduced the adherence of foodborne pathogen *Listeria monocytogenes* AMDK2 (47.46 ± 0.17%) to Caco-2 cells.	*Lactococcus lactis* AMD17	*in-vitro*	[44]
Weight gain in albino rat (129.33 g) and the serum cholesterol level of these rats decreased gradually, with a significant reduction of 4.1 mg/100 ml	*Bifidobacterium bifidum* and *Lactobacillus acidophilus*	*in-vivo*	[45]
Exhibit hypocholesteromic effects and probiotic attributes	*Lactobacillus plantarum YD5S, L. plantarum YD9S, L. pentosus YD8S, L. paraplantarum YD11S*	*in-vitro*	[31]

Future prospects

The ethnic origins of traditional fermented milk products, along with limited research into their technological and functional properties, have kept these products largely confined to their regions of origin. However, recent advancements in dairy and food science have revealed the vast market potential of these indigenous fermented milk products. As a result, many food companies are now working to bring attention to this emerging segment, aiming to make these traditional products more popularise. Global awareness of the health benefits of bioactive dietary compounds with specific functions has rapidly increased. The nutraceutical market was valued at $454.55 billion, with a projected compound annual growth rate (CAGR) of 9% from 2021 to 2033 [46, 47]. The rising demand for functional foods and natural dietary supplements has driven food researchers to pay greater attention to fermented food products [48]. Modern fermentation processes use selected starter cultures with desirable traits to ensure consistency and commercial success. By integrating data-driven approaches such as culturomics, metagenomics, and metabolomics, research on these fermented milk products can enhance culturing methods of microorganisms, which are traditionally involved in fermentation. This approach also helps validate traditional beliefs about the benefits of these products. These findings could regulate the guidelines for production technology and contribute to the development of a new segment of functional foods in India.

Conclusion

Fermented milk products is a part of the human diet for centuries due to their pleasant taste and also by their cultural variations. *Mishti doi*, a traditional fermented milk product of Bengal and the fermentation process is associated with local culture and varies greatly from one place to another. Indo-Aryan ethnoliguistic group are known as bangalees or Bengalis, are historically connected to the production of *Mishti doi.*Local people generate income by selling their creations. This study provided a comprehensive overview of the current knowledge for the production of *Mishti doi*, identifying gaps in research and

suggesting potential areas for future exploration. Growing consumer awareness has influenced the research into the functional aspects of indigenous fermented milk products, with an aim to explore their potential as biotherapeutic and nutraceutical alternatives in medicine. To ensure the safety of *Mishti doi* for human consumption, standardized protocols, fermentation process guidelines, and quality control measures must be established for its production. Over time, numerous studies have been conducted to uncover the health benefits of fermented foods, scientifically validating their functional properties.

Declarations

Ethics approval and Consent to participate

Informed consent was obtained from all participants prior to data collection. Participants were clearly informed about the purpose of the study, any potential risks and benefits involved. The survey was conducted by open ended questionnaire and face to face interviews, it did not involve any kind of clinical procedure or risk to the respondents of North Bengal region. Hence, institutional ethics committee of the University of North Bengal waived the need for approval. All participants interviewed were above 18 years and have agreed voluntary to give information on the ethnic heritage of their region.

Clinical trial number

Not applicable

Consent for publication

The authors approve the publication of this manuscript.

Competing interest

The authors have no competing interest to declare.

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Author Contribution

PC has collecting the data and written the manuscript, and KG has revised and finalized the manuscript.

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Data Availability

All data and materials have been presented in this paper.

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Figures

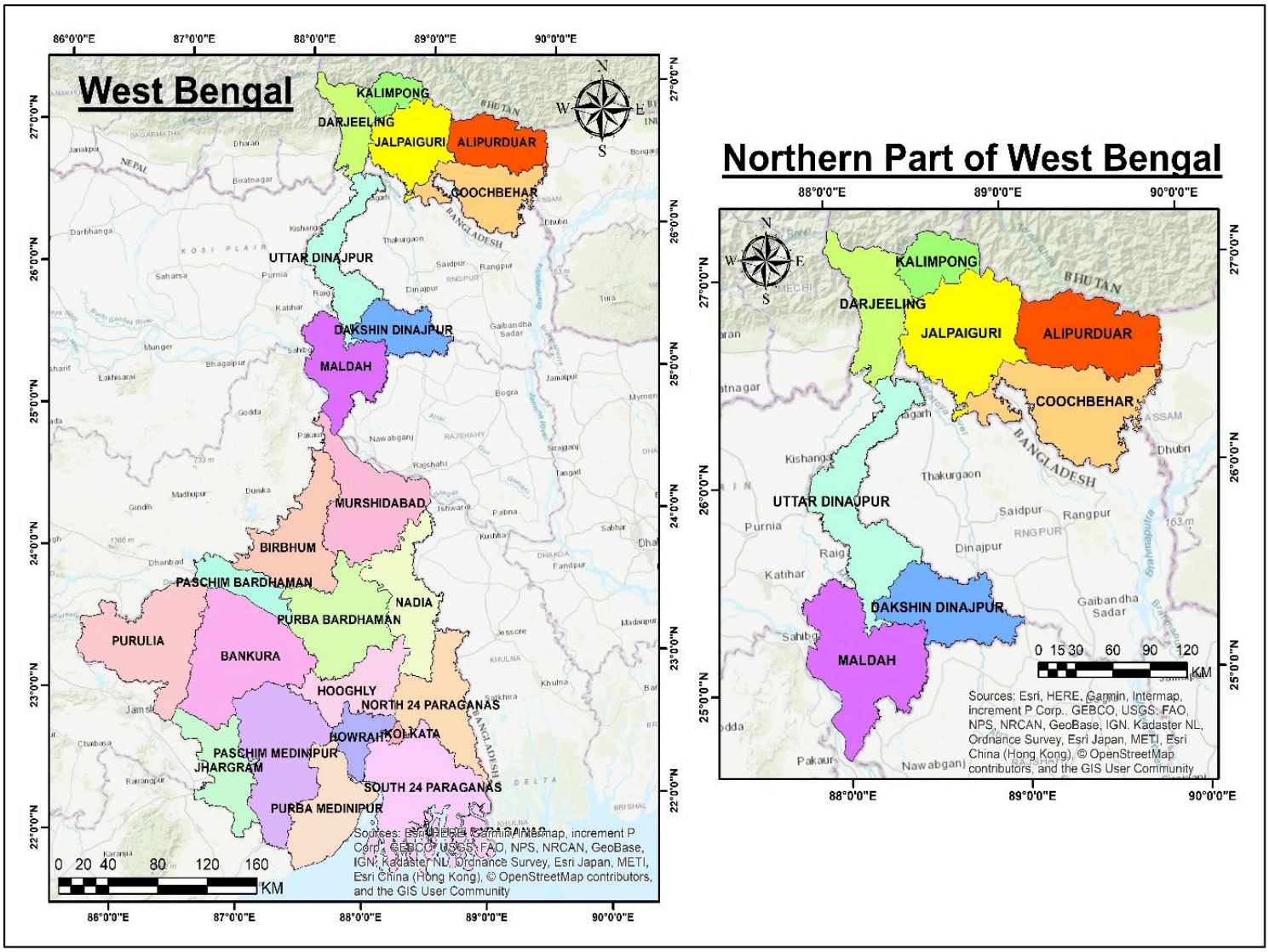

Figure 1

Geographical map showing the regions of West Bengal, India selected for the collection of *Mishti doi* samples

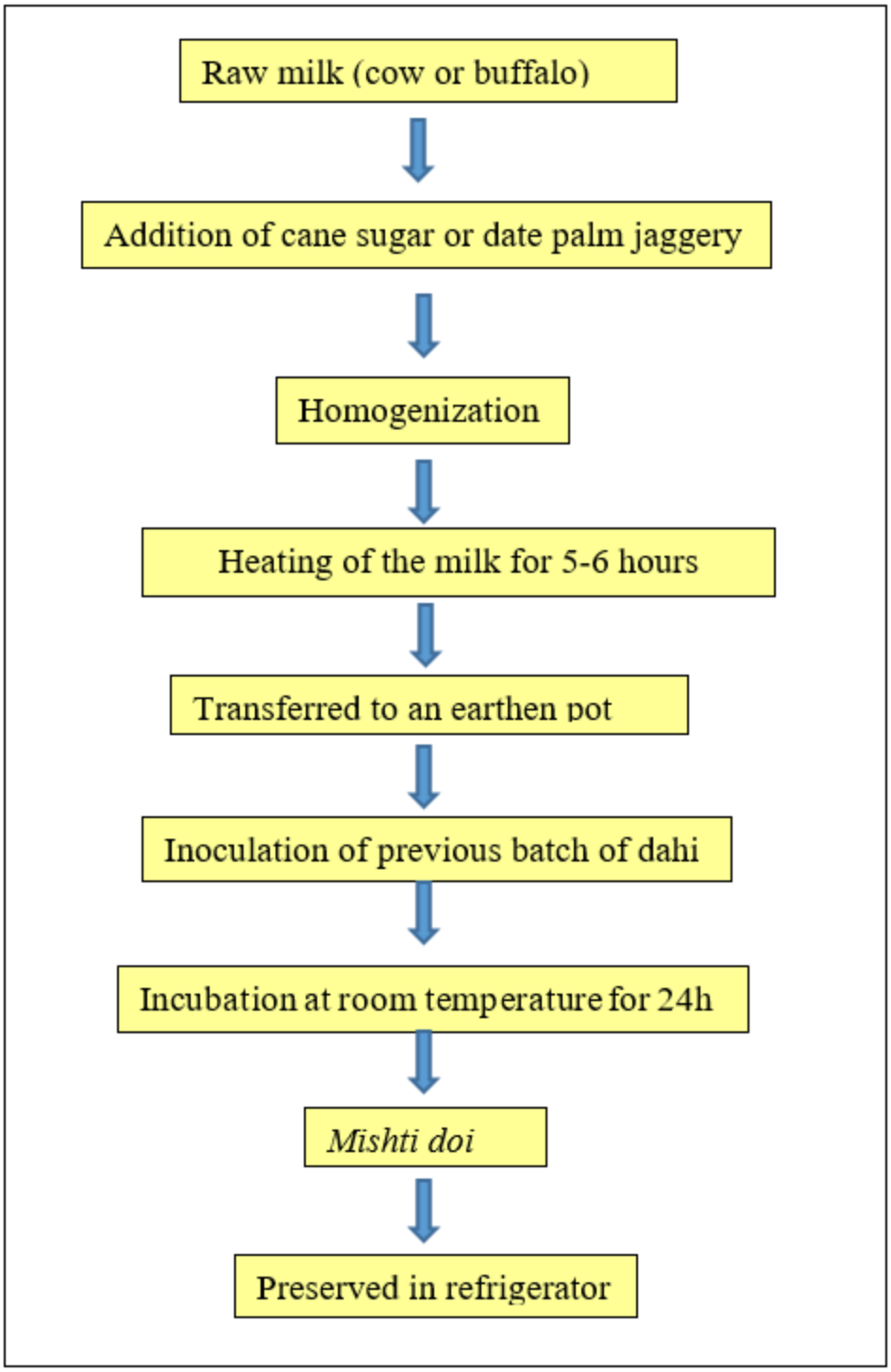

Figure 2

Flow chart for the preparation of *Mishti doi*

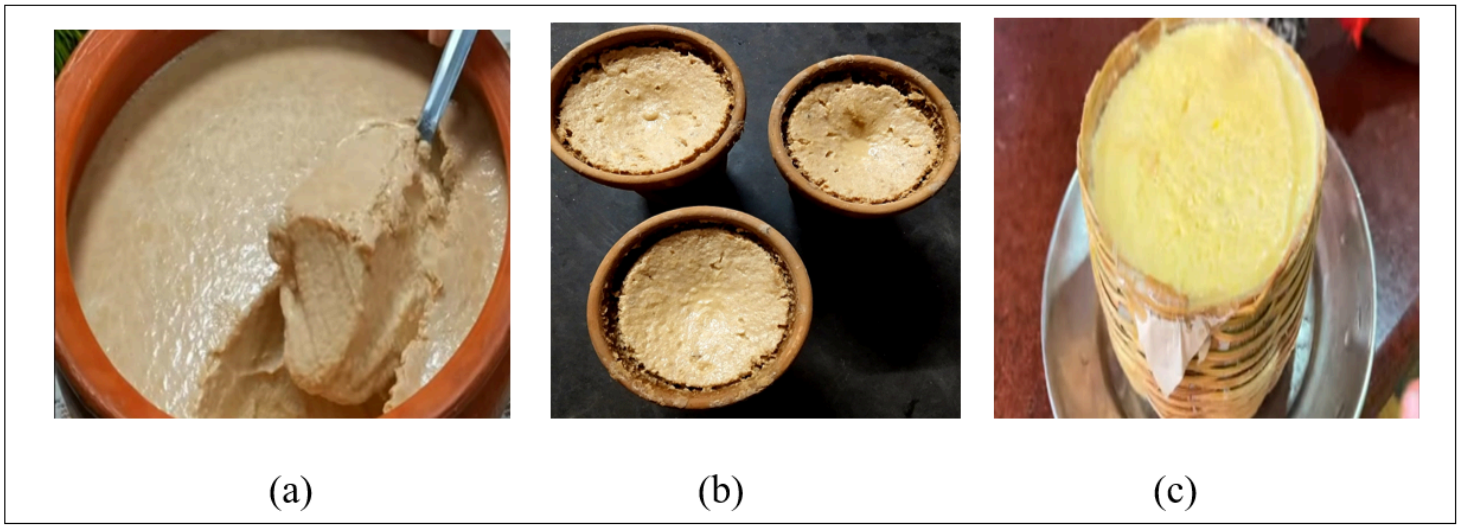

Figure 3

Different types of *Mishti doi* (a) *Lal doi* or *Chakku doi* (b) *Kheer doi* (c) *Jhuri pata doi*

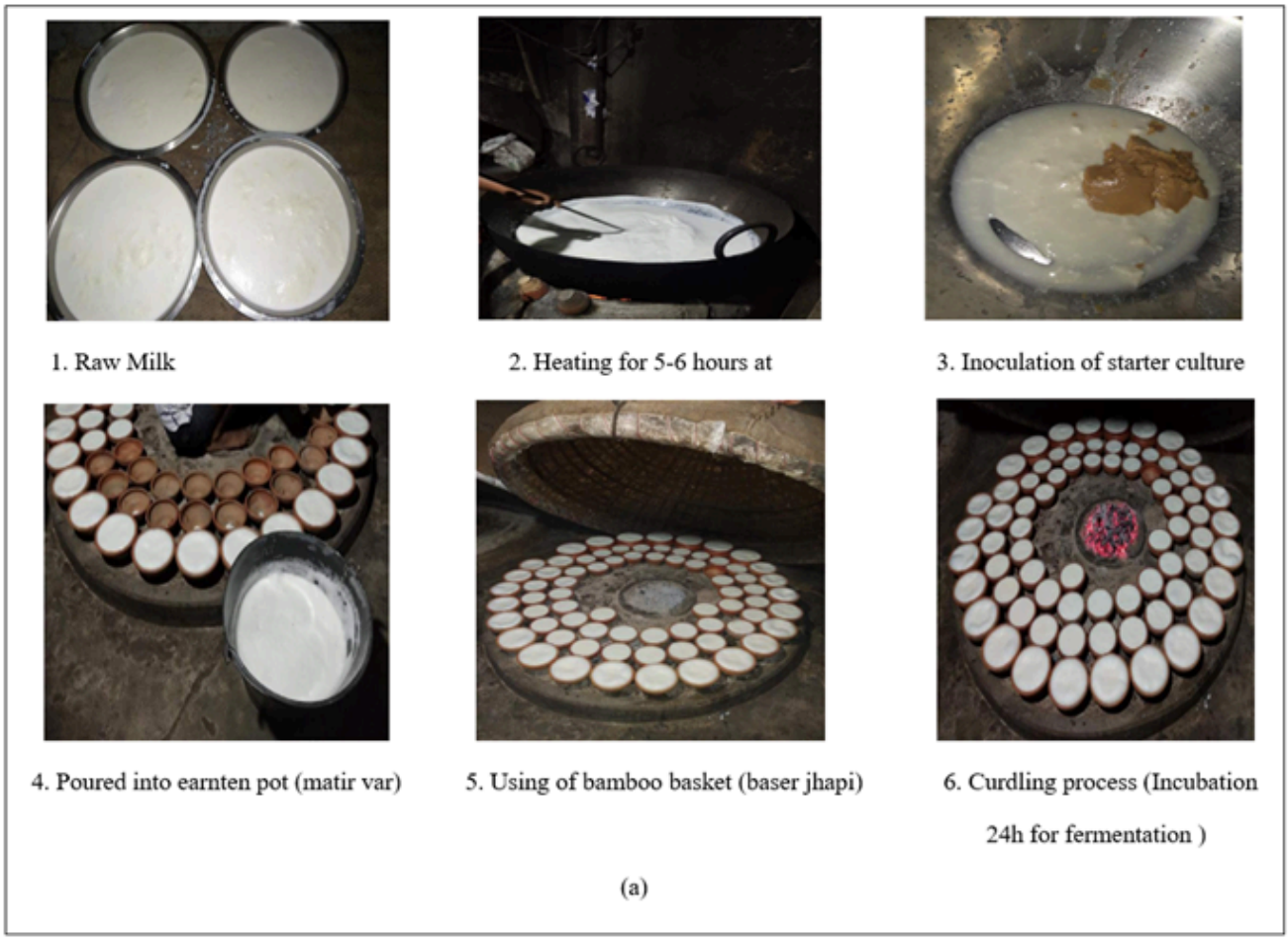

Figure 4

(a) Preparation of *mishti doi* by using sugar (b) Preparation of *mishti doi* by using jaggery (*khejur gur*)

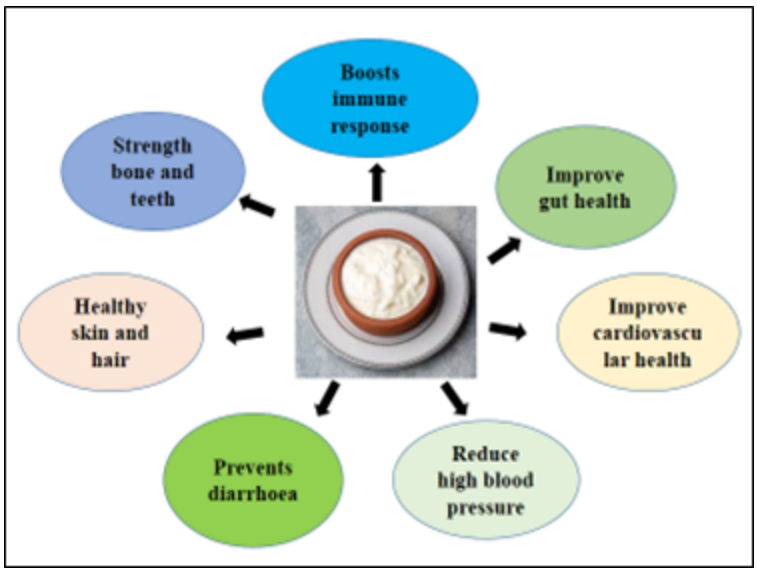

Figure 5

Health benefits of Dahi