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Manner of Ethiopian Dairy Products Processing and Their Nutritional and Health Importance

Jemal Mohammed[1*]

[1]Department of Food Science and Postharvest Technology, College of Agriculture and Environmental Science, Arsi University, P.O.Box 193, Asella, Ethiopia.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Dairy products play a vital role in human nutrition and protecting against numerous diseases. Understanding the meticulous characteristics of traditionally processed dairy products as well as appropriate examination of the indigenous processing steps are important in order to vouch for suitable manufacturing procedure and protocols for commercialization. In Ethiopia, fortunately, some evidence is available on the general characteristics and processing practices of traditional dairy products nevertheless a few data is available about their role in human nutrition and health. Therefore, the objective of this review was to assess and compile information on processing of traditional dairy products in Ethiopia and their nutritional and health benefits. *Ergo*, *ayib* , *arera, kibe*, *neter kibe, aguat*, *ititu,* and *dhanaan* are the major dairy products encompassed in this review.

Keywords: Dairy products; ergo; fermentation; nutrition; health.

1. INTRODUCTION

Dairy products such as cream, butter, yogurt, kefir, and cheese have been produced and consumed worldwide for millennia [1]. The nutritional and functional effects of various fermented dairy products have been practiced by numerous generations. However, scientific

**Corresponding author: Email: mmjemal@gmail.com;*

research on the implication of fermented milk products has been accepted starting from 1910. The benefits of fermented dairy products are due to biologically active components that are present in native milk and also, the result of their suitably modulated activities produced through the action of probiotic bacteria, in the sour milk products [2,3,4]. In addition to modification of several milk components the probiotics may act also directly as preventive agents, or in therapy of some contagious, atopic, tumor or other severe diseases The health-promoting effect of the pre fermented functional foodstuffs materializes directly through interaction with consumed microorganisms or probiotic effect or, as a result of action of microbial metabolites generated during the fermentation process or biogenic effect indirectly [5]. The most significant biogenic metabolites are vitamins, proteins, peptides, oligosaccharides, and organic acids, including short chain fatty acids.

Furthermore, dairy products are widely used as major portion of the total functional foods in world market and are currently used as best source of probiotic developments [6].In Europe, dairy products are the major contributors in the functional food market by contributing approximately 60% of the total functional food [7]. The global functional foods market expects to reach $204.8 billion by 2017 [8].

Like other countries, Ethiopians have been producing and utilizing many dairy products as part of their diet for centuries. The major types of traditional dairy products are *ergo* (spontaneously fermented milk), *kibe* (butter), *arrera* (defatted buttermilk), *augat* (whey)*, niter kibe* (ghee) *.ayib* (cottage cheese) ,*ititu* (fermented milk curd) and *dhanaan* (fermented camel milk). However, the process is through the application of traditional fermentation methods and several also spice and herbs are used not just as flavorings, but also as medicine and preservatives. Using spices and herbs in milk processing and preservation is indispensable to improve dairy products palatability and quality .However, there is a limitation to reviewing these and other related information and thereby to delivering such synthesized and summarized data to the beneficiaries.

Therefore, the objective of this paper was to review traditional dairy products processing methods as well as their nutritional and health benefits. Besides it focused on the functional properties of some important spices and herbs used during processing and preservation.

2. MILK PROCESSING METHOD IN ETHIOPIA

The collected fresh milk is transferred from the pre-smoked utensil commonly known as *akole* (made from woven grass and, in pastoral regions, from skin of animal), into a smoked storage utensils. These apparatus are washed with hot water and then smoked by diverse aromatic plants *such as Achynthes aspera, Ruta graueolens*, *Eucalyptus globulus*, *Ruta cymbopogon* , *Acacia nilotica, Cordia glarfa, Cordia ovalis/ Combertum molle* , *Deinbollo kilimandshorica*, *Syzygium guinecnse*, *Heeria reticulala* ,*Olea africana* , *Juniferrus procera* and *Ocimum hardiense* [9-12]. Smoking can be done either by introducing the smoking chips into the vessels and whirled inside for a few minutes with the lid of the vessels on or by upturning the vessel over the smoking chips until the smoke dies out. The vessels are allowed to cool and cleaned by a clean cloth after which fresh raw milk is introduced [6]. In some cases, the inside of the lid of these vessels is scrubbed with plant leaves.

According to the local understanding, the practice of smoking the vessels used for collection and storage of the milk has two main advantages: firstly, that the smoke flavor imparts a special taste and odor to the products, and secondly, to disinfect the vessels due to antimicrobial action, therefore reducing spoilage and extending the shelf life of the milk and milk product [13]. Milk and dairy products prepared in poor hygienic conditions create a great health problem to consumers. Despite the fact that the combined effect of spices/herb which were incorporated during preparation and processing and the lactic acid bacteria with antagonistic activity can reduce the risk of spoilage and pathogenesis [14].

3. COMMON DAIRY PRODUCTS IN ETHIOPIA

In Ethiopia, the major milk products that are produced by traditional methods are *ergo, kibe, ayib, neter kibe, arera, augat, ititu and dhanaan.* These all are fermented products and the fermentation process is usually carried out using natural wild microorganisms, without using defined starter cultures to initiate fermentation process.

3.1 *Ergo* (Spontaneously Fermented Milk)

Ergo is one of fermented milk product which has some similarity to yoghurt. It is semi solid and has a pleasant taste and odor. *Ergo* is the main product that is used as foundation for processing of other various fermented milk products such as *kibe, neter kibe, ayib, arerra,* and *augat*.

During *ergo* production, milk is collected in traditional milking utensil called *akole*, and stored and fermented in *kussa*. *Ergo* is flavored with fresh leaves of *Ruta chalepensis var. tenuifolia, O. hadiense, Coriandrum sativum* mixed with green *Capsicum annuum* (locally called *kochikocha)* and mashed *Allium sativum*. And then stored it in smoked vessels takes 2–4 days to ferment depending on the ambient temperature [15]. If the temperature during incubation is too high, fermentation is rapid and over souring occurs, causing a separation of the liquid and solid phase and gas production, thus leading to deterioration of appearance and texture, particularly when unsmoked vessels are used. Smoking slowed souring, improved flavor and slowed the growth of coliforms. At lower temperatures 20^0C and in smoked containers, *lactococci* dominated whereas lactobacilli were predominant in unsmoked containers and at higher [13]. Under souring is a problem in the highlands or low temperature areas in rare cases and thus it requires an extended fermentation time of 3–5 days and depending on the temperature, *ergo* can be stored from 15 to 20 days [16]. When consumed fresh, it constitutes low health risks due to its low pH, at which most pathogenic and spoilage organisms are inhibited [17].

Ergo is consumed as a side dish with different traditional foods like *injera, genfo* (*markaa),qinchea, bread (dabbo) and anchotea*. It is mostly used as a nutritional support to sick people, children and to pregnant and lactating women. In many part of Ethiopia, *ergo* is given to male members of the family, whereas the pastoralist more preferred fresh milk. Additionally, it is also served to respected guests.

3.2 *Kibe* (Traditional Butter)

Kibe is semi-solid at room temperature. It has a pleasant taste and odour when fresh, but with increased storage, changes occur in odor and taste, unless refrigerated or further processed into *neter kibe* (traditional ghee) by boiling with spices.

For *kibe* production, *ergo* is used as raw material. *Ergo* is churned by *wesso* which is traditional churners in the Oromya region. The churn is usually pre smoked, by which in addition to the preservative effect and the reduction of the processing time by the heat, smoking is common to improve the flavor of the *kibe* [18].

Churning can be done by either the churn is positioned on a mat consisting of a layer of grass, straw, sheepskin, and then rocked forwards and backwards or the churn is shaken on a person's lap. The women of some pastoralist families carry the sour milk in goat skin bags on their backs and agitate it with their elbows while walking or working [19]. They can detect the time when butter starts to form through sound change of the milk. Normally, the women insert the grass through the hole into the churn if small *kibe* granules observe to the grass surface, the churning is continued. After some minutes, the grass is again put in through the opening. If it is clean, it indicates that the *kibe* granules have combined into larger grains.The churn is then rotated on its base by which the grains in the center form lumps of butter that are then skimmed off. The *kibe* is then kneaded in cold water and washed to take away visible residual buttermilk.

Kibe is considered as a luxurious food and it is utilized also by children of weaning age and the elderly. It is used as oil for preparation of meat and vegetable stew/*wott* eaten with *injera*, unfermented bread *(kitta*) and fermented bread *(dabo)*. It is also used as a skin cosmetic and for hair dressing.

3.3 *Neter Kibe* (Traditional Ghee)

Neter kibe has an attractive appearance, light yellow color, pleasant odor and good taste. It has relatively good keeping quality and is the most stable of all traditionally processed fermented milk products. Its superior keeping quality allows storage for more than a year without any change [6].

N*eter kibe* is processed only at household level by heating *kibe* in an iron pan or clay sauce pan to evaporate the water from *kibe*. Heating is continued until bubbling ceases. Simultaneously, for flavor improvement, spices such as *O. hadiense, O. basilicum,* mashed *Allium sativum* (garlic), and grounded *Zigeber officinale* (ginger) are added. Then *neter kibe* is decanted into another container leaving the curd material in the pan.

Neter kibe is a popular food and is considered as a major staple item in the diet .It can be used either as oil, for the preparation of different kinds of stew like *siga wot,chiko, dorro wot, atakilt wot* or as a side dish with a variety of traditional foods (*dabbo, anababero)*. Furthermore, during special traditional ceremonies, it is also used to roast coffee beans.

3.4 *Arrera* (Defatted Sour Milk)

Arrera has a pleasant odor and taste. It has faintly smoother appearance and thinner consistency, while thicker than fresh milk. *Arrera* is a byproduct during *kibe* production and serves as raw material for cottage cheese *(ayib)* manufacture.

For *arrera* production, *ergo* is used as a typical raw material. Fresh leaves of *Ruta chalepensis var. tenuifolia,* and *O. hadiense* are most commonly added for flavoring, followed by mashed green *Caps. annuum and A. sativum* . It has a shorter shelf life compared to all other fermented milk products only 24–48 hr, even when smoke is applied to the equipment used for its storage [20]. It contains protein, residual fat, milk salts, lactic acid, lactose and vitamins [21].

Arrera is consumed in all parts of the country and used as a beverage either plain or spiced. In rural part of Ethiopia [22], it is given to weaning age children, elderly and is particularly considered as food of children and women. Due to its moderately short shelf life and some traditional taboos or beliefs, *arrera* is not sold in the market. Therefore, when the production is surpluses, it is given to calves, lactating cows and dogs.

3.5 *Ayib* (Traditional Cottage Cheese)

Ayib is a soft curd-type cheese which is made from the buttermilk after the production of butter. It can be produced at home level, in small enterprises and in large scale industries. As for *ergo* and *kibe*, milk souring initiates the process of *ayib* production, although it is mainly prepared by heating the butter milk (*arerra*) to about 50^{o}C in a suitable container (an iron or clay pot) [19,23]. This temperature is maintained for 20–25 min until curd coagulates [24,25], after which it is allowed to cool gradually and the curd is separated from the whey through a fine mesh cloth or a sieve. Since then *Ayib* is spiced with *kochikocha, Caps. annuum,* salt and other herbs and spices.

Ayib can be given to children of weaning age as well as to the elderly. It is mainly consumed as side dish with different traditional foods such as *Kocho* and *kitfo* (traditional food made up of high quality ground meat). In addition to home consumption, because of its low production costs and local availability *ayib* is one of the major products for sale by reasonable price. *Ayib* is also used to produce *Metata Ayib* which widely consumed in Northwest part of Ethiopia. *Metata Ayib* is produced by spontaneous fermentation for 20 days with incorporation of different locally available spice [14]. It has better microbiological quality and longer shelf life up to one year in comparison with traditional cottage (a*yib)*.

3.6 *Augat* (Acid Whey)

Aguat is the liquid that remains after *ayib* is prepared from the *arera* and most of the fat and protein in the milk have been removed during the butter and *ayib* processing. It is thus usually given to animals (calves, dogs) and occasionally consumed by humans. It does, however, rich in whey proteins, amino acids, lactose and minerals [6].

3.7 *Ititu* (Fermented Milk Curd)

It has a good taste and pleasant odor. *Ititu* is preferred and prepared by the pastoralist communities to use during dry season as there is a lack of fresh milk [26]. During i*titu* production, fresh milk is collected in a well smoked fermenting vessel called *gorfa* which is wicker work of selected plants into a lidded container with a capacity up to three litters while the Borenas make it from leather. The *gorfa* is washed with hot water; air dried, rinsed with fresh milk and smoked for a few minutes with selected plants such as *Acacia nilotica, Cordiagharaf, Cord. ovalis, Combretummolle*. Then the *gorfa* scrubbed with fresh leaves of *O. basilicum, O. hadiense, or Endostemontereticaulis*. These processes used to improve the flavor of product and help to prevent spoilage [14]. Small amount of milk (up to 300 ml) is added to the *gorfa* and is allowed to ferment naturally. When the milk coagulates, whey is removed by wooden pipette and an extra volume of fresh milk is added. The process of whey removal and addition of fresh milk is repeated several times until the product is concentrated enough.

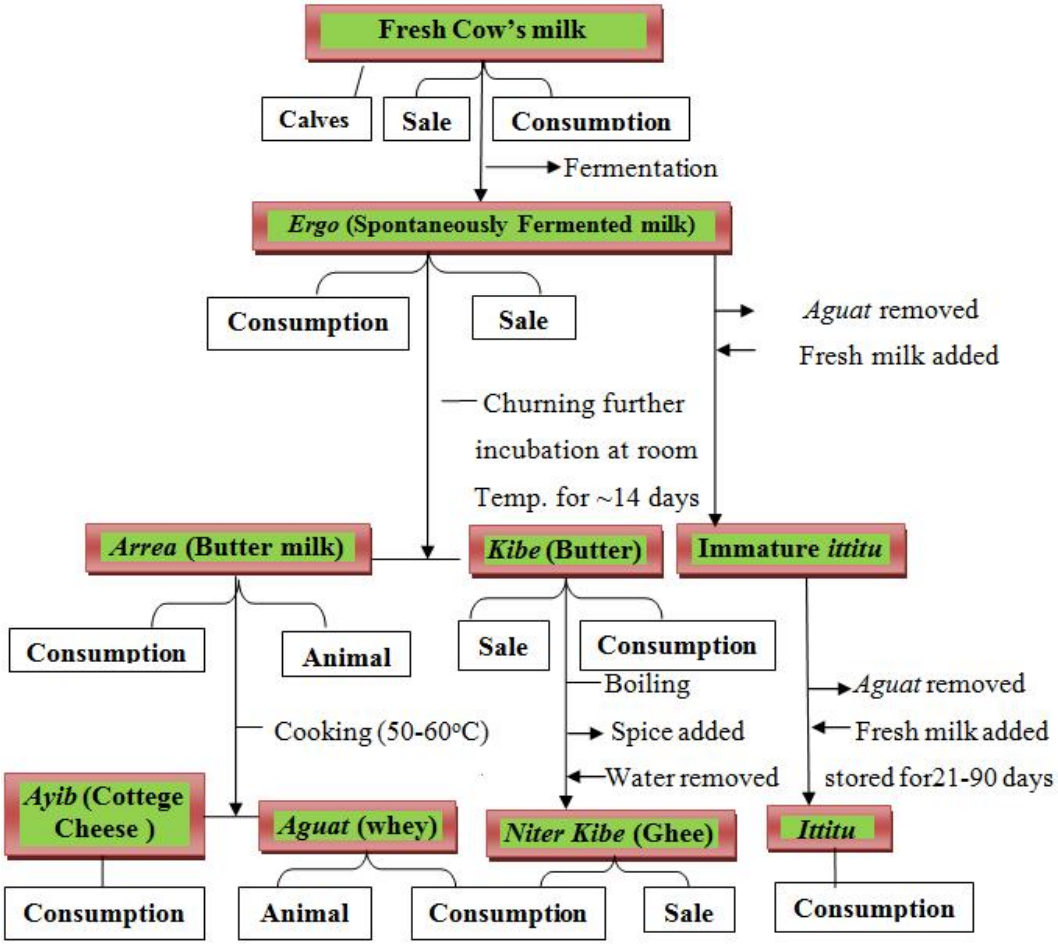

Fig. 1. Process and utilization of dairy product in Ethiopia

After removal of the whey and addition of fresh milk, the lid is replaced capturing some smoke from a piece of charcoal, thereby decontaminating the inner surface of the lid. If this is not done, the risk of spoilage by molds is increased. Over-souring and risk of spoilage due to the high frequency of surface mold growth are some of the major troubles encountered [6]. If the product is stored for a long time without refrigeration this can lead to over-souring. People control such problem by adding some amount of roasted fenugreek powder, pre-mixed with fresh raw milk and/or melted ghee, prior to serving [23]. *Ititu* is either used for direct consumption or spiced and stored for later use. It can be stored for up to 90 days [6].

Ititu is consumed as side dish with different traditional foods such as *marqaa* , *chachabissa* ,*kitta* and *neter kibe*. It can also be consumed as food or drink alone. *Ititu* is also served to much respected guests as well as to weaning age children and the elderly.

3.8 *Dhanaan* (Fermented Camel Milk)

Dhanaan is the major fermented camel milk to rural and urban settlements in Somali Regional State [27]. It has better nutritional quality and shelf life (up to five months) as compared to *ititu* [28]. During *dhanaan* production, fresh milk placed in a cleaned and smoked container, and keeping it in ambient temperature for about 12-24 hour to allow spontaneous fermentation without using a starter culture [23]. However, some of the producers mentioned that when a small amount of previously fermented milk is added as a starter into fresh camel milk it takes only 6 hr. to obtain *dhanaan* [29,30]. The milk in the container should be kept closed; otherwise the fermentation process does not take place. This suggests that the microorganisms

responsible for souring or fermentation of camel milk are probably thermophilic anaerobic types [29,30].

4. NUTRITIONAL AND HEALTH BENEFITS OF DAIRY PRODUCTS

Eventually milk is a composite of numerous nutrients. Most of the constituents in milk do not work in separation, but rather interact with other constituents. Often, they are involved in more than one biological process, sometimes with conflicting health effects, depending on the process in question. One such example is milk fat. The traditional diet-heart paradigm, developed in the 1960s and 1970s, held that consumption of fat, and saturated fat in particular, raised total cholesterol and low-density lipoprotein cholesterol levels, leading to coronary heart disease [31]. Currently, many national and international bodies recommend consumption of lower-fat dairy foods. However, the scientific rationale behind this recommendation is still debated. It is vital to remember that dietary fats, in addition to being a concentrated energy source, serve as an important delivery medium for fat-soluble vitamins and contain various fatty acids (e.g. conjugated linoleic acid) and bioactive factors beneficial to health (e.g. triacylglycerols and phospholipids) [32,33]. Similarly, to consider even saturated fatty acids as one uniform group of fats may be an over-simplification [34,35], since individual fatty acids have specific functions depending on their chain length.

Minerals found in dairy foods, such as Ca, Mg, P and K, have been concerned in the management of elevated blood pressure and cardio metabolic syndrome. And numerous epidemiologic studies have shown that children and adults with higher concentrations of calcium and phosphate in their dental plaque had a lower occurrence of dental caries [36,37]. When caseino-phosphopeptides from milk react with phosphate and calcium at the tooth surface they produce colloidal amorphous calcium phosphate complexes which promote remineralization of enamel in humans [38]. An in vitro study also indicated that, yoghurt containing casein phosphopeptides prevented demineralization of tooth enamel and enhanced its remineralization [39].

Another study found that children who never consumed cheese or ate it only once in the five-day period recorded had an average of 1.5 surfaces affected by caries, whereas those who ate cheeseon average at least once a day were caries free [40]. A similar study suggested that high intake of yoghurt may reduce the prevalence of dental caries in children but showed no association between caries and milk or cheese consumption [41]. The exact mechanism by which certain dairy products are anti-cariogenic is still unclear, but the current evidence suggests that consumptionof these milk products can protect against dental caries. Both hard cheese and milk probably decrease risk of dental caries, and that hard cheese also possibly decreases the risk of dental erosion [42].

Nowadays the growing interest of consumers towards therapeutic products has led to incorporation of probiotic cultures in different milk products. Lowering the pH of food products through fermentation is a form of food preservation. Other benefits of fermentation include improvement of food quality through food digestibility and to increase essential amino acids, vitamins and protein [43]. As of its smaller lactose content, fermented milk can be tolerated by individuals having a reduced ability for lactose digestion [44]. These dairy proteins play a vital role in food intake regulation, satiety and metabolic distracts relating to obesity. Blood pressure may be affected by lactic acid bacteria, milk proteins, peptides and calcium.

Milk fat contains convinced components having the functional significance. Antimicrobial effects are exerted by sphingolipids and their active metabolites either directly or upon their digestion. Milk products and their components take part in regulating the body mass through satiety signals. Therefore, whey proteins include physiological milk components for individuals with metabolic syndrome and obesity. Whey protein in high protein milk products may improve insulin sensitivity and reduce fat deposition. The bioavailability of trace elements and minerals i.e. manganese, calcium, magnesium, iron, selenium and zinc is also improved by milk proteins and peptides [10].

Casokinins, casomorphins, immunopeptides, lactoferricin, phosphopeptides, and lactoferrin are bioactive peptides and milk proteins which are a common supplement to the functional foods [45] which have a number of biological effects ranging from anti-carcinogenic activity to different effects on lowering blood pressure [46,47]. These proteins and peptides also improve the bioavailabilityof minerals and trace elements, such as calcium, magnesium, manganese, zinc, selenium and iron [48].

Table 1. Bioactive compounds, functional and antimicrobial properties of herbs and spices

Spices/Herb	Part Used	Component	Major functional properties	Antimicrobial properties	Reference
Garlic */ Allium sativum*	Bulb	Polyphenol & organosulfur diallyl thiosulphinic acid	Reducing cholesterol and LDL Combating sickness and cold, Improve heart health, Reducing blood pressure in hypertensive people, Anti-aging effects	Escherichia coli, Staphylococcus aureus, Bacillus cereus, Bacillus subtilis, Candida albicans *A. niger*, *Acari parasitus*, *Pseudomonas aeruginosa*	[14,20 ,59-63]
Cinnamon*/Cinnamomum verum*,	Bark	Cinnamic aldehyde , polyphenol	Flavoring agent, Antioxidant activity, Lowering cholesterol in the blood, Mouth refreshing effects, Antimicrobial effect	Aspergillus parasiticus *Salmonella spp. E. Coli*, *Pseudomonas fluorescens* and *Bacillus licheniformi*	[59,60, 64-69]
Fenugreek/*Trigonella Foenum Graceum*	Seed	Amino acid /4-hdroxy leucine	Improving the function of insulin, Lowering blood sugar levels, Coloring and flavoring ingredient	*Aspergillus flavus, Penicillium roqueforti, Candida lipolytica*, *Staphylococcus aureus*	[22,23, 59,60]
Basil / *Ocimum basilicum*	Leaf	Eugenol, Angiotensin Converting Enzyme Polyphenol	Lowering blood pressure, Reducing blood sugar level, Fighting inflammation, Antioxidant ,anti-asthmatic, anti-tumor	*Aspergillus flavus,* , *Candida lipolytica*, *Staphylococcus aureus* ,*Pediococcus halophilus*	[20,22,23,59,60, 71-74]
Ginger/*Zingiber Officinale*	Rhizomes	Gengerols antioxidants	Flavoring, Treat nausea ,Antii-inflammatory, Help to management pain	*Staphylococcus aureus; Bacillus spp., Escherichia coli, Salmonella spp.*	[20,22,23,59,60]
Turmeric */Curcuma longa*	Root	Polyphenol	Antioxidant, Has anti-inflammatory, Colorant anti-microbial and anti-carcinogenic properties ,Fight Alzheimer's,	*Aspergillus flavus, Penicillium roqueforti, , Candida lipolytica*, *Staphylococcus aureus*	[59,60,75]
Rosemary/ *Rosmarinus Officinalis*	Leaf	Alpha-pinene ,rosemanol ,antioxidants	Prevent allergies, Antioxidant ,Improve brain function & memory, anti-carcinogenic effects	*Bacillus cereus, Staphylococcus aureus, Vibrio parahaemolyticus*	[59,60,76-81]
Oregano/ *Lippia Abiyssinica*	Leaf	Carvvacrol, flavinods	Pleasant odor	*Salmonella spp., Bacillus cereus, E. coli O157:H7,L.monocytogenes.*	[59,60, 78-82]
Thyme */Thymus Vulgaris*	Leaf	Thymol, Geraniol, carvvacrol,	Anti-carcinogenic effects	*Vibrio parahaemolyticus, Aspergillus Penicillium genus*	[59,60, 80-83]
Parparika pepper/ *Capsicum Annum*	Fruit/berries	Capasanthin ,Capsorubin	Colorant, Increase fat burning (weight management), Help to combat cancer	*V. parahaemolyticus, S. aureus, S. tiphy , E. coli*	[59,60, 79-81]

It is recommended that viable lactic acid bacteria interfere with the colonization and subsequent proliferation of food borne pathogens, thus preventing the manifestation of gastrointestinal infections including diarrhoea [49]. Probiotics have also been reported to effective in prevention of various gastrointestinal infections [50] to reinforce the barrier function of the intestinal wall, thereby possibly preventing the absorption of some antigens that used to prevent the allergic reactions in individuals of high risk [50,51].

Consuming yogurt and other dairy products is associated with a reduced risk of weight gain and obesity as well as of CVD [52]. Many studies have also shown an effect of yoghurt or lactic acid bacteria on enhancing levels of certain immunoreactive cells or factors [49]. Cytokine production, phagocytic activity, antibody production, T-cell production etc. are increased with yoghurt consumption or with lactic acid bacteria.

Nowadays several milk-derived growth factors are increasingly used in pharmaceuticals products, such as in the treatment of skin disorders and gastrointestinal diseases [53]. Health promoting effects in humans were observed in leg ulcers and psoriasis [54,55] in gut health [56] and in tissue bone regeneration [57].

5. FUNCTIONAL PROPERTIES OF SPICE AND HERBS

Spices and herbs have been used since ancient times. While their roles have also been studied *in vivo* and *in vitro*. Spices and herbs have been employed as flavor, colour, aroma, enhancing agents and for preservation of foods. They have also confirmed abundant health benefits in preventing and treating a wide variety of diseases such as cancer, inflammatory, aging, neurological, metabolic, and cardiovascular diseases [54]. Since they are huge source of polyphenolic substances or antioxidants which assist in impediment the oxidation of molecules by inhibiting the initiation or propagation of oxidizing chain reactions by free radicals and may decrease oxidative damage to the human body [57,58]. In Ethiopia many kinds of spices and herbs are used in dairy processing methods. In this review, the most commonly used spice/herbs that have conferred medicinal or functional properties to dairy foods dealt below.

6. CONCLUSION

This paper reviewed and discussed some of the findings regarding the processing methods and role of dairy products as functional foods. Several studies have consistently shown that a regular intake of dairy components associated with a reduced risk of several diseases like hypertension, obesity, cancer, diabetes, and some infectious diseases. Also there are also abundant kind of applications of these bioactive diary components such as phosphopeptides are currently used as both dietary and pharmaceutical supplements. Many of the components found in milk may have a protective effect against the onset of disease that occurs as a result of overweight,

Ever since ancient times, spices and herbs have been used not just as food flavoring but also for its medicinal properties. The antioxidant and antimicrobial constituents exist in spices permits them to be used as useful preservatives. Fortifying spices in dairy product may result in improvement in the health and medical condition of human being. Herbal products with promising health benefit, should comply with the regulatory requirements with respect to care, worth, quality testing and marketing authorization procedures. It should be devoid of any side effect. And further systematic scientific studies and documentation are is a need.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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