

Probiotic bacteria in relation to Ethiopian dairy industry

Daniel Getahun¹, Tewodros Alemneh^{2*}, Dawit Akeberegn³, Mebrate Getabalew¹ and Derbie Zewdie¹

¹College of Agricultural and Natural Resource Science, Department of Animal Science, Debre Berhan University, Ethiopia.

²Woreta City Office of Agriculture and Environmental Protection, South Gondar Zone, Amhara Regional State, Ethiopia.

³Debre Berhan City Municipality Office, Meat Inspection & Hygiene, Semen Shewa Zone, Amhara Regional State, Ethiopia.

Accepted 13 August, 2019

ABSTRACT

This review is undertaken to compile the role of probiotic bacteria in relation to Ethiopian dairy industry. Despite Ethiopia is the first in Africa and the fifth in the world by cattle population, the dairy industry is not strengthened and unable to satisfy the demand of the country's human population due to several factors such as the lack of adequate market chains, inappropriate production systems, and poor genetic makeup of dairy animals for milk production. Ethiopia produces about 4 billion liters of milk per year. Per capital consumption is very low, estimated at about 20 liters per year, though rising consumption levels in Addis Ababa have brought it to about 40 liters per year. At the current production rate, there's an annual shortage of about 18 billion liters. Around 98% of milk is produced in small holder farmers so they stay for the milk for long period of time by using natural fermentation mechanisms, which are probiotic bacteria. *Lactobacillus*, *Bifidobacterium*, *Saccharomyces cerevisiae*, *Escherichia coli* and *Bacillus* species are important for fermentation, a process to soften food texture and alter its composition in such a way that it will require minimal energy both in cooking and preservation processes. These bacteria are found in fermented milk and also associated with human body, especially in the gastrointestinal tract and mouth. Some members of these microbes have a dual role in transforming milk into diverse dairy fermented products (cheese, kefir, yoghurt, etc.) and play an important role to inhibit colonizing pathogenic bacteria. From probiotic bacteria, lactic acid bacteria are the most numerous and very essential as compared to others.

Keywords: Probiotic bacteria, dairy industry, fermentation, lactic acid bacteria.

*Corresponding author. E-mail: tedyschow@gmail.com. Tel: 251 9 20 49 98 20.

INTRODUCTION

Ethiopia has one of the highest cattle populations in Africa, estimated at 60 million heads. Though camels, goats, and to a lesser extent sheep, are used as milk-producing animals, about 90% of milk comes from cows. Unfortunately, milk production and consumption are very low. Milk is mainly used for household consumption, not marketed and any surplus is usually converted into butter and sold in local markets. Ethiopia produces about 4 billion liters of milk per year. Per capital consumption is very low, estimated at about 20 liters per year, though rising consumption levels in Addis Ababa has brought it

to about 40 liters per year. The Food and Agriculture Organization (FAO) recommends that the per capital consumption of milk should be about 200 liters per year, meaning 22 billion liters of milk is required for the country. At the current production rate, there's an annual shortage of about 18 billion liters (Tegegne, 2018).

In Ethiopia, a large proportion of milk is consumed in the fermented form through the application of traditional fermentation methods. The main fermented milk products include *ergo* (sour milk), *ititu* (milk curd), *ayib* (cottage cheese), *neter kibe* (spiced butter), *kibe* (traditional

butter), *agwat* (whey) and *arerera* (sour defatted milk). In East and South East part of Ethiopia, fermented (suusac) camel milk is widely consumed, while in North West part, fermented *Metata Ayib* is prepared using traditional cottage cheese with different spices of probiotics (Berhanu and Tsehayneh, 2014).

Probiotics are live microorganisms that can be formulated into many different types of products, including foods, drugs, and dietary supplements. Probiotic is a relatively new word that is used to name the bacteria associated with the beneficial effects for the humans and animals (AHRQ, 2011). *Lactobacillus* and *Bifidobacterium* are most commonly used probiotics in food and feed. Other microorganisms such as yeast, *Saccharomyces cerevisiae*, and some *Escherichia coli* and *Bacillus* species are also used as probiotics. Lactic acid bacteria (LAB) which have been used for food fermentation since the ancient time, can serve a dual function by acting as food fermenting agent and potentially health benefits provider. For the use of LAB as probiotics, some desirable characteristics such as low cost, maintaining its viability during the processing and storage, facility of the application in the products, resistance to the physicochemical processing must be considered (Danfeng et al., 2012). The objective of this review is to collect the role of probiotics in Ethiopian dairy industry.

LITERATURES REVIEW

Ethiopian dairy sector: Existing scenario

Ethiopia has large number of ruminants (59.5 million cattle, 30.70 million sheep, and 30.20 million goat populations) (CSA, 2017) having high contribution for milk production, meat consumption and generates income from export of live animals, meat, edible organs and skin. Out of those, the country has 10 million dairy cows producing approximately 3.2 billion liters on average of 1.54 liters per cow per day over a lactation period of 180 days (Tefera, 2010). The farm-level value of the milk is estimated to Birr 16 billion (\$ 0.6 billion). The values of other important animal products and services include blood, traction, transport, and manure for organic fertilizers and fuel. Estimated calf consumption and wastage of milk is 32% of the milk produced. Households consume approximately 85% of the milk collected, 8% of the milk is processed into products with longer shelf life, and 7% is sold during peak production in the wet seasons, rural farmers, not part of formal cooperatives, face challenges marketing their milk as most regions experience a surplus. More surplus milk may be processed at home into local cheese or butter. For most subsistence farmers in all cultures in Ethiopia, the daily decision on how to allocate milk is decided by the head women in the household and is dependent upon

season, number of children in the household, presence of sick family members, and daily financial needs (MoARD, 2007).

Ethiopian dairy industry and probiotic bacteria

The private sector

The private sector constitutes an important part of the dairy sector in Ethiopia. It is engaged in providing farm inputs (feed and veterinary drugs), animal health care and milk processing and storage equipments and serves as an important market outlet for milk and milk products. Commercial processors are those adopting modern technology with the majority of their output being pasteurized milk in packs of 500 ml. Currently there are over 22 medium and large-scale dairy processing companies in Ethiopia with nine of them operating in Addis Ababa and the rest in other major regional cities (Table 1) (Land, 2011).

Industry players (partners)

There are various players (from individuals to higher institutions) in the dairy sector that play sundry roles at different levels. These include: farm input suppliers, producers of different scales, cooperatives and unions, extension service providers, traders, processors, distributors, industry facilitators, development partners and consumers as end users. Earlier studies (Lemma et al., 2008; Yilma et al., 2011) reported that weak linkages among the different actors in the dairy value chain (Figure 1) are some of the important factors that contribute to the poor development of Ethiopia dairy sector.

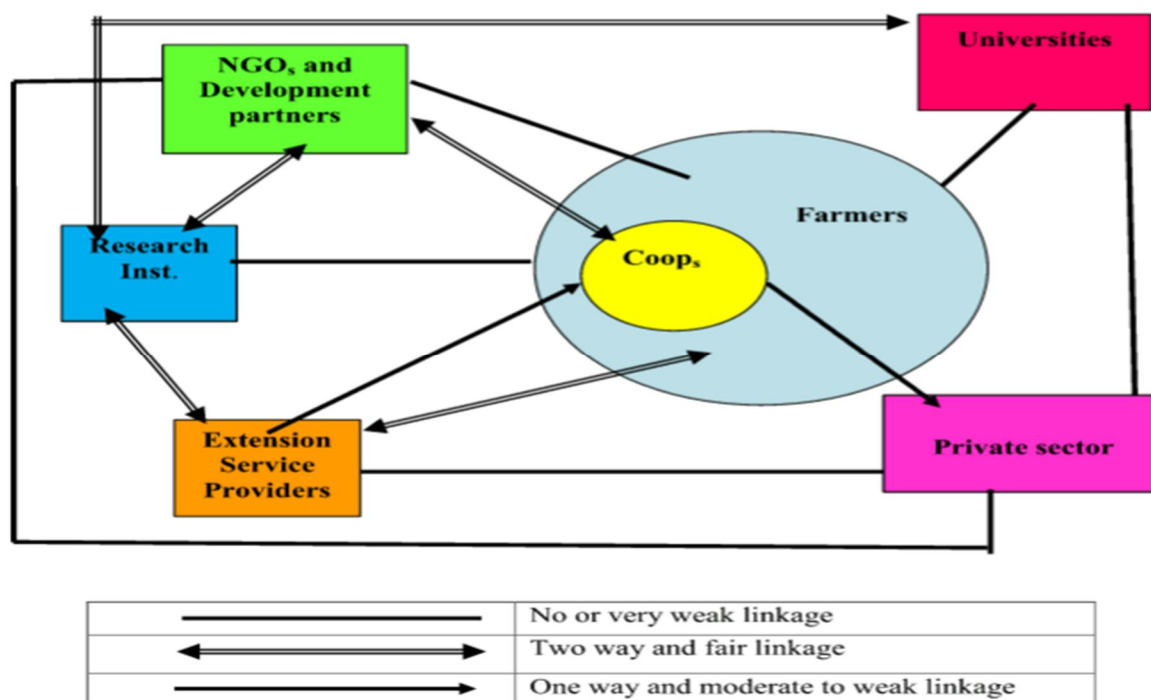
Dairy cooperatives and unions

Cooperatives play a significant role in ensuring sustainable supply of raw milk to the dairy industry by coordinating the flow of milk from their members and assisting them by supplying the required dairy farm inputs. Emanu (2009) reported that 180 cooperatives are engaged in milk production and marketing operating in different parts of the country. However, this number makes only 0.74% of the total number of agricultural and non-agricultural cooperative and 2% of agri-based cooperatives in the country. According to the same author, there are a total of four (two each in Amhara and Oromia Regions) milk production and marketing cooperative unions that are formed by cooperatives for better marketing capability and bargaining power. Ada'a Dairy Cooperative is the most successful, while Selale and Asella Dairy Cooperative Unions are currently

Table 1. Major private dairy enterprises operating in different parts of Ethiopia.

No.	Dairy enterprise	Location	Year of establishment	Daily processing capacity, (in liters)	Attained average capacity, (in liters)
1	Sebeta Agro Industry (Mama Dairy)	Sebeta	1998	35,000	30,000
2	Lame Dairy Processing (former DDE)	Addis Ababa	2008	60,000	30,000
3	Dire Dawa Dairy Processing Enterprise	Dire Dawa	1972	20,000	20,000
4	MB PLC (Family Milk)	Addis Ababa	2003	15,000	7,000
5	Yadeni Dairy Farm (Bora Milk)	Addis Ababa	2008	15,000	7,000
6	Ada'a Dairy Cooperative	Debre Zeit	1998	15,000	3,000
7	Lema Dairy	Debre Zeit	2004	10,000	3,000
8	Berta and Family plc	Addis Ababa	2000	9,000	6,000
9	Genesis Farm	Debre Zeit	2001	4,000	4,000
10	Holland Dairy	Debre Zeit		4,000	4,000
11	Almi Tiku Wetet (Almi Fresh Milk)	Hawassa		4,000	3,000
12	Ruth and Hirut Dairy Farm	Addis Ababa	2008	4,000	1,500
13	Abay fana Awash Agro-Industry	Adama		3,500	2,000
14	Chuye Milk and Milk Products Processing	Addis baba		3000	1000
15	Fantu and Family Dairy Farm	Addis Ababa		2,500	2,000
16	Zemen Milk	Mekelle		2,000	150
17	Pinguin International Business plc (cheese world)	Addis Ababa		1,800	600
18	Life Milk Processing Enterprise	Sululta		1,500	1,500
19	Semit Agro Industry/Enat Milk	Mojjo			
20	Beral Milk	Addis Ababa	1991		
21	Harmonius Agro Industry	Adama			
22	Jantekel Dairy Union (Facil Milk)	Gondar		1,200	300

Source: Land (2011).

**Figure 1.** Linkages among the various actors in the Ethiopian dairy value chain (Yilma et al., 2011).

performing fairly well (Yilma et al., 2011).

Local and international development partners

Different national and international development partners have been involved in the development of the country's dairy sector by providing material and technical support to smallholder farmers, dairy cooperatives and unions and the private sector. The major development partners currently involved in dairy development at different levels and in different dairy potential areas of the country include: Netherlands Development Organization (SNV), Food and FAO, Heifers International Organization and Non-Governmental Organizations (NGOs) (Yilma et al., 2011).

The Ministry of Agriculture

Dairy development in the country is undertaken by the Government represented by the Ministry of Agriculture (MoA). MoA is the government's main arm for agricultural policy formulation and technical supervision including designing strategies, preparation of programs, capacity-building, providing trainings and coordinating national agricultural development projects. MoA's main objective is to improve the livelihood and income of producers by increasing livestock productivity and profitability. This is done through the provision of extension services to smallholder dairy producers on different improved livestock technologies, building of technical capacity of producers, promotion of collective action and facilitation of linkages with other national, regional and international organizations engaged in dairy research and development for further innovations (Yilma et al., 2011). Dairy cooperatives and unions provide a regular market outlet to member and non-member small holder producers that produce small amounts of milk daily.

Small holder dairy producers

Small holder dairy producers dominate the dairy industry at the production and are the users of the extension services provided by various development partners. Different players are linked and interact with small holder dairy producers at various levels based on the type of ongoing joint venture activities. The actors are extension agents, various non-governmental and international development partners mainly FAO, SNV, cooperatives, research and higher educational institutions (Yilma et al., 2011).

Small holder farmers, however, lack the required technological, organizational as well as institutional capacities. Lemma et al. (2008) reported them to be less organized and distant from market outlets, lack

economies of scale and institutions for risk management and face higher transaction costs. Urban and peri-urban small holder producers are the main suppliers of raw milk to milk processors of different scales. One of the major commercial processors (Sebeta Agro Industry) has its own dairy farm, but depends on outside sources for 99% of its raw milk intake (Haile, 2009).

Probiotic bacteria in Ethiopian dairy industry

The probiotic bacteria are bacteria that associated with fermented dairy products. These probiotic bacteria are found from fermented milk also associated and found in human body, the gastrointestinal tract, including the mouth, etc. Some member of these microbes have a dual role in transforming milk into a diverse dairy fermented products (cheese, kefir, yoghurt, etc.) and play an important role to and inhibit colonizing bacteria. International Dairy Federation has been defined a fermented milk product as the milk product produced from skimmed milk or not with specific cultures. The micro-flora in fermented milk is kept alive until during consumption and may not favor the growth of any pathogenic germs (Panesar, 2011).

Probiotic bacteria are important for fermentation, a process to soften food texture and alter its composition in such a way that it will require minimal energy both in cooking and preservation process. Thus, less fuel will be used for cooking and eliminates the need of preservation as fermentation increases the shelf life of food. These advantages make fermentation a highly desirable technique in rural communities where resources for cooking and preservation are scarce. Dairy products are one of the most important fermented foods consumed across the world (Chelule et al., 2010). Microorganisms involved in dairy fermentations can produce biologically active molecules and enzymes, giving the final food product an additional health value. Consequently, the bacteria can act as a microbial factory to enrich foodstuff, for which bacterial viability through the GIT or during the product storage is not absolutely required (Farnworth and Champagne, 2015).

Traditional fermented dairy products in Ethiopia

These fermented products have different vernacular names such as *ititu*, *ergo*, *meomata* or *geinto* among the Oromo, Amhara, Wolayta or Sidama people, respectively. The fermentation process is usually carried out using natural wild microorganisms, without using defined starter cultures to initiate fermentation process. In most cases, fermentation of dairy products carried out through the propagation of the initial microorganism, with serious of microbial succession governed by chemical changes and ambient temperatures in the fermenting milk. In rural

areas, especially among the pastoralists, raw milk is mostly kept in properly smoked container and fermented milk from a previous fermentation uses as source of inoculums. LAB from the inner walls of the container also become established and serves as starter culture. Incubation temperature does have significant role in the lowlands and the quality and taste of the fermented product may be more or less uniform. The fermented dairy product may also be serving as raw material for the production of traditional butter (*qibe*) and butter milk (*arrera*). The butter milk can be further being processed into *Ayib* or traditional cottage cheese and whey (*aguat*). Lactic acid bacteria produce several metabolic products including potential antimicrobial activities, fatty acids, organic acids, hydrogen peroxide and diacetyl. Therefore, LAB plays a significant role in food fermentation and they have also antagonistic effects against food borne pathogenic microorganisms and help to improve biochemical features of fermented foods. They are also produces different types of compounds that important characteristic aroma, color and flavor of fermented foods (Berhanu and Tsehayneh, 2014). (Table 2)

Ergo (sour milk)

Ergo is an Ethiopian traditional naturally fermented milk product with more or less the same characteristics to yogurt. It is normally smooth and thick with consistence or uniform appearance and normally has a white color if prepared carefully. This fermented product is usually semi-solid state with a pleasant odor, aroma and taste. It generally constitutes a sour milk product from which other products may be further produced. Depending on the storage temperature, it can be stored for 15 to 20 days and it has been reported that *Lactococcus garvieae* and *Lactococcus lactis* subsp. *lactic* were dominant (Esayas et al., 2008).

Ititu (concentrated sour milk)

The name *ititu* is used for concentrated fermented milk prepared and consumed by the Borana tribes in southern part of Ethiopia. This pastoral/farmer community prepares *ititu* during the rainy season when milk is available in abundance for later consumption during the drier seasons when fresh milk supply is markedly scanty. The product has good keeping quality and remains acceptable for about two months at ambient temperature (25 to 30°C) and can be stored from about two months to three months the traditional processing and consumption pattern of *ititu* is well described by Gonfa et al. (2001). It is consumed as a side dish with traditional porridge or thin-baked cereal chips. It can also be consumed as food or drink alone. It is considered as one of the special foods and served to much respected guests as well as to weaning-age children and the elderly.

Ayib (Ethiopian cottage cheese)

In Ethiopia, small-holder milk processing is based on sour milk mainly due to high ambient temperatures, consumer's preference and increased keeping quality of sour milk. *Ayib* is a traditional Ethiopian cottage cheese made from sour milk after the fat is removed by churning and produced by slowly heating naturally soured milk until a discrete curd mass develops and floats over the whey. The whey is traditionally known as *aguat*. It is an acidic product. *Ayib* is a popular milk product widely consumed by various ethnic groups in different part of the country (Anteneh et al., 2011).

Qibe (traditional Ethiopian butter)

Qibe is a traditional Ethiopian butter which is made from *ergo* and not from cream. It has a white to yellowish color, depending on age and is semi-solid at room temperature. It has a typical diacetyl taste and flavor when fresh, but extended storage at ambient temperatures results in putridity and rancidity. *Qibe*, without further processing, is used for hairdressing and as a skin cosmetic mainly by women. Generally, *qibe* is used in the diet after processing into *nitir qibe* (traditional ghee), by heating it to boiling after selected types of spices are added to it. *Nitir qibe* is basically used for the preparation of stews made of legumes or meat, which are eaten with *enjerra*, fermented pancake-like bread. In Addis Ababa, where consumption of *qibe* is believed to be high, over 54% of milk is converted to *qibe* (CSA, 1995).

Camel raw and fermented (Suusac) milk

The arid and semi-arid part of East Africa land is estimated to have 11 million camels which accounts for 58% of the world camel population. Camels in this portion of the world produce over 2/3 camel milk (1.3 million tons per year) (Jans, 2008). Ethiopia is estimated to have the third herd of camel in the world after Somalia and Sudan in the order. Apart from camels from Afar region and Northwest border part of Ethiopia, Somali Region has an estimated population of more than two million herds. This region provides milk for the society in the region as well as neighboring countries such as Somaliland and Djibouti on a daily basis. Milk from camel plays an important role to provide nutrition for of pastoral communities.

Metata Ayib

Metata Ayib is a traditional fermented milk product prepared from cottage cheese that widely consumed in Northwest Ethiopia (Table 3). Production of *Metata Ayib* is carried out using traditional cottage cheese with

Table 2. The most common and significant species of bacteria in fermented milks.

Species of common milk bacteria	Species of milk bacteria
<i>Lactobacillus cldophilus</i>	<i>Leuconostoc dex tranicum</i>
<i>Lactobacillus bulgarcus</i>	<i>Leuconostoc tactis</i>
<i>Lactobacillus cosez</i>	<i>Streptococcus cremoris</i>
<i>Lactobacillus helveticus</i>	<i>Streptococcus lactis</i>
<i>Lactobacillus lactis</i>	<i>Streptococcus lactis</i> subsp. <i>diacetylactis</i>
<i>Leuconostoc cremors</i>	<i>Streptococcus thermophilus</i>

Source: Gilliland (1987).

Table 3. Spices used in the preparation of *Metata Ayib*.

Scientific name	Common name	Amharic name	Part of the plant used
<i>Brassica nigra</i>	Mustard	Senafitch	Seed
<i>Coriandrum sativum</i>	Coriander	Dimbillael	Seed
<i>Zingiber officinale</i>	Ginger	Zingebil	Rhizomes
<i>Allium sativum</i>	Garlic	Netchishinkurt	Bulbs
<i>Ocimum basilium</i>	Basil	Zekakibe (Basobila)	Seed
<i>Ruta graveolence</i>	Rue	Tenadam	Seed

Source: Tsehai et al. (2013).

different spices through spontaneous fermentation for 20 days. *Metata Ayib* has a long shelf life up to one year in semi-solid form but more than ten years in dry form. In contrast *Ayib* has a shelf life of only a few days. The property of *Metata Ayib* has not been fully understood and characterized (Eyassu, 2013).

Dominant and useful microorganisms in dairy products

Lactic acid bacteria (LAB): LAB comprises a diverse group of Gram positive, non-spore forming cocci, coccobacilli or rods. In most cases they are anaerobic, microaerophilic or aero tolerant in their oxygen demands. The lactic acid bacteria consist of several genera, which include *Streptococcus*, *Enterococcus*, *Lactococcus*, *Luconostoc*, *Lactobacillu* and *Pediococcus*. Based on similarities in physiology, metabolism and nutritional needs, these genera are grouped together. A main similarity of such bacteria members is that all produce lactic acid as a main sole end product during the fermentation of sugars (John, 1998). Species LAB belong to *Streptococcus* and *Leuconostoc* produce the small amount of acid in comparison to others; while the homo fermentative species of *Lactobacillus* produce the highest quantities of lactic acid. Hetero fermentative *Leuconostoc* and *Lactobacillus* species convert glucose to about 50% lactic acid, 25% acetic acid and ethyl alcohol and 25% carbon dioxide. This is important in leavening and in flavor development of certain bread like fermented foods

(Jay, 1994).

Role of LAB in food preservation

Lactic acid bacteria are widely utilized to produce fermented foods with good quality nutrition value, aroma and flavor as well as with safe metabolic activities. During the growth of LAB in foods, they use and metabolize sugars for the production of different metabolites and organic acids (Nigatu, 1998). In common dairy fermented products like yogurt, mainly lactic acid are produced by the help of starter culture bacteria to avoid the growth of undesirable microorganisms introduced from the environment.

CONCLUSIONS

In summary, Ethiopia has large number of ruminant populations, but the dairy industry is not strengthened and unable to satisfy the demand of the country's population due to different reasons like, market chain, production system, poor genetic make-up of dairy animal for milk production and other factors. Ninety eight percent (98%) of the milk, produced by small holder farmers, is traditionally prepared with the aid of probiotic bacteria that are important for fermentation of milk. Probiotics also produce different types of compounds that have important characteristics for aroma, color and flavor of fermented milk and important for preventing spoilage

which prolongs the shelf-life of the milk. In addition, they react against the action of photogenic bacteria by reducing the P^H of the milk.

ACKNOWLEDGEMENTS

Authors forward their special thanks to Debre Berhan University Staffs and the Communities for their logistic and material supports.

REFERENCES

- AHRQ** (Agency for Health care Research and Quality), **2011**. Safety of probiotics to Reduce Risk and Prevent or Treat Disease .Evidence Report/ Technology Assessment. No. 200.
- Anteneh T, Tetemke M, Mogessie A, 2011**. The inhibition of some food borne pathogens by mixed LAB cultures during preparation and storage of *Ayib*, a traditional Ethiopian cottage cheese. *World J Dairy Food Sci*, 6(1): 61-66.
- Berhanu A, Tsehayneh G, 2014**. Fermented Ethiopian dairy products and their common useful microorganisms: A review. *World J Agric Sci*, 10(3): 121-133.
- Chelule PK, Mokoena MP, Gqaleni N, 2010**. Advantages of traditional lactic acid bacteria fermentation of food in Africa. *Current Research, Technology and Education Topics in Applied Microbiology and Microbial Biotechnology A. Méndez-Vilas (Ed.)*.
- CSA, 1995**. Report on livestock, poultry and beehives population (private peasant holdings). Central Statistical Authority Statistical Bulletin, Addis Ababa, Ethiopia, pp. 243.
- CSA, 2017**. Agricultural Sample Survey 2016/2017 Report on Livestock and Livestock Characteristics (private peasant holdings) Addis Ababa Ethiopia. 2 (9-12).
- Danfeng S, Salam I, Saeed H, 2012**. Recent Application of Probiotics in Food and Agricultural Science. DOI: 10.5772/50121.
- Emana B, 2009**. Cooperatives: a path to economic and social empowerment in Ethiopia. *Coop Africa Working Paper No. 9*. International Labour Office (ILO), Dares Salaam, Tanzania. pp. 44.
- Esayas A, Fekadu B, Amutha S, 2008**. Effect of temperature and pH on the antimicrobial activity of inhibitory substances produced by lactic bacteria isolated from Ergo, Ethiopian traditional fermented milk. *Afr J Microbiol Res*, 2: 229-234.
- Eyassu S, 2013**. Chemical composition and microbiological quality of *Metata Ayib*: a traditional Ethiopian fermented cottage cheese. *Int Food Res J*, 20(1): 93-97.
- Farnworth ER, Champagne CP, 2015**. Production of probiotic cultures and their incorporation into foods. In: *Probiotics, Prebiotics, and Synbiotics: Bioactive Foods in Health Promotion*. Vol. 20 eds Watson R. R., Preedy V. R., editors. (Amsterdam: Elsevier), 303–318.
- Gilliland E, 1987**. Characteristics of Cultures used for the Manufacture of Fermented Milk Products. In "Milk- the Vital Force". Proceedings of the XXII International Dairy Congress, The Hague, September 29 - October 3, 1986. Edited by the Organizmg Committee of the XXII International Congress. D. Reidel Publishing.
- Gonfa A, Howard A, Foster B, Wilhelm H, Holzapfel C, 2001**. Field survey and literature review on traditional fermented milk products of Ethiopia. *Int J Food Microbiol*, 66(3): 173-186.
- Haile G, 2009**. The impact of global economic and financial crisis on the Ethiopian dairy industry. Impact of the global economic crisis on least developed countries' (LDCs) productive capacities and trade prospects: Threats and opportunities, Least Developed Countries Ministerial Conference, UNIDO, UN-OHRLLS, 3-4 December 2009, Vienna International Center, Austria.
- Jans C, 2008**. Identification and diversity of lactic acid bacteria responsible for spontaneous acidification of camel milk for the purpose of developing a defined susac starter culture. *ILW Food Biotechnology*, ETH Zurich.
- Jay M, 1994**. *Modern Food Microbiology*. 4th ed. Van Nostrand Rainhold, New York.
- John L, 1998**. *Laboratory Manual for Food Microbiology Laboratory*. University of Wisconsin, Madison.
- Land O'Lakes, 2011**. List of existing major milk processors in Ethiopia. Land O'Lakes, Addis Ababa, Ethiopia.
- Lemma T, Tegegne A, Puskur R, Ranjitha P, Hoekstra D, 2008**. Moving Ethiopian smallholder dairy along a sustainable commercialization path: missing links in the innovation systems: Improving Productivity and Market Success (IPMS) Project, ILRI, Addis Ababa, Ethiopia.
- MoARD, 2007**. Livestock Master Plan Study Phase I Report Volume T – Sociological Aspects.
- Nigatu A, 1998**. Systematics of *Lactobacillus* and *Pediococcus* isolates from fermented tef (*Eragrostis tef*) and kocho (*Ensete ventricosum*) and microbiological status of the baked products. PhD dissertation, Department of Biology, Addis Ababa University, Ethiopia. pp. 1-102.
- Panesar PS, 2011**. Fermented dairy products: Starter cultures and potential nutritional benefits. *Food Nutr Sci*, 2: 47-51.
- Tefera TL, 2010**. Commercializing dairy and forage systems in Ethiopia: An Innovation Systems Perspective. ILRI – IPMS. Working Paper No. 17.
- Tegegne A, 2018**. Why Ethiopia's Dairy Industry can't meet Growing Demand for Milk. Retrieved June 05, 2019, from The Conversation: <http://theconversation.com/why-ethiopia-dairy-industry-cant-meet-growing-demand-for-milk-100067>.
- Tsehail G, Amiha K, Berhanu A, 2013**. Microbial profile of *metata* (fermented cheese) and the role of spices as an antimicrobial agent against spoiling microorganisms in traditional fermentation process. MSc Thesis, Haramay University, Ethiopia. pp. 1-75.
- Yilma Z, Emmanuelle GB, Ameha S, 2011**. A Review of the Ethiopian Dairy Sector. Ed. Rudolf Fombad, Food and Agriculture Organization of the United Nations, Sub Regional Office for Eastern Africa (FAO/SFE), Addis Ababa, Ethiopia, pp. 81.

Citation: Getahun D, Alemneh T, Akeberegn D, Getabalew M, Zewdie D, 2019. Probiotic bacteria in relation to Ethiopian dairy industry. *Microbiol Res Int*, 7(3): 24-30.
