PharmaNutrition 5 (2017) 84–88

Contents lists available at ScienceDirect

PharmaNutrition

journal homepage: www.elsevier.com/locate/phanu

Camel milk and its fermented products as a source of potential probiotic strains and novel food cultures: A mini review

Amal Bakr Shori

King Abdulaziz University, Faculty of Science, Department of Biological Sciences, Jeddah 21589, Saudi Arabia

ARTICLE INFO

Keywords:
Functional dairy products
Lactic acid bacteria
Probiotics
Camel milk

ABSTRACT

Probiotic is a dietary supplement of live microorganism that contributes to the health of the host. The combination of lactic acid bacteria (LAB) and probiotics is widely used in fermented foods such as dairy products. A number of LAB have been isolated and identified as probiotics from the milk of different animal species. Camel milk is considered as health promoting and being consumed widely as a part of the staple diet in some areas of Africa and Asia. Camel milk can be used as a potential source of probiotics in dairy products. Therefore, this review focuses on previous studies of isolation and identification of LAB with potential and novel probiotic strains from raw camel milk and its products.

1. Introduction

Lactic acid bacteria (LAB) and their metabolites play a key role in enhancing microbiological quality and shelf life of fermented dairy products [1,2]. They have an essential role in most fermented food for their ability to produce various antimicrobial compounds promoting probiotic properties [3].

The Food and Agriculture Organization [4] defined probiotics as live microorganisms that when present in sufficient amounts in the digestive tract may confer health benefits on the host. The combination of starter culture and probiotics (Bifidobacterium, Lactobacillus) is widely used in fermented foods such as dairy products [1,5].

A number of LAB have been classified as potential probiotics. One of the main requirements in dairy food industry is the appropriate selection and stability of probiotics for desirable texture and flavor. In addition, quality assurance criteria for potential probiotics should be characterized as the ability to survive during passage through the gastrointestinal tract, including low pH, bile salt concentrations and digestive enzymes, high survival rate (minimum 10^6–10^7 CFU/g) [6]. The initial microbiological quality of raw milk affects the final dairy products [7].

Besides camel milk being part of the staple diet in some areas of Africa and Asia is also considered as health promoting [8]. It is common practice in these regions to recommend consumption of camel milk either in a fresh or sour state [9] for controlling diabetes and its complications such as high cholesterol levels, liver and kidney disease, decreased oxidative stress and delayed wound healing [10]. Camel milk and its fermented products did not receive enough attention and few studies have been carried out on the isolation and characterization of potential probiotic strains (*in vitro*) from camel milk. Therefore, this review focuses on previous studies of isolation and identification of LAB with potential and novel probiotic strains from raw camel milk and its products. However, functional properties of strains isolated from camel milk were not discussed in this review.

2. Potential probiotic strains from raw camel milk and its products

Raw camel milk and its fermented products can be a good source of potential probiotic strains. *Lactobacillus*, *Bifidobacterium* and *Enterococcus* are the most commonly strains used as probiotic bacteria [11–13]. A mixture of different species of bacteria e.g. *Lactobacillus fermentum*, *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactococcus lactis* subsp. *lactis*, *Enterococcus faecium*, and *Streptococcus thermophilus* (Table 1) have been identified as the predominant bacteria in camel milk. Maurad and Meriem [26] have isolated two *Lactobacillus plantarum* strains (SH12 and SH24) from traditional butter made from camel milk (shmen) as starter cultures for camel milk fermentation. These two strains showed rapid acidification activity, proteolytic activity, antibacterial activity and high survival rate after freeze-drying. A previous study reported that distribution of LAB in raw camel milk from Morocco had a high variety of dominated species such as *Lactococcus lactis* subsp. *lactis* (17.5%), *Lactobacillus helveticus* (10%), *Streptococcus salivarius* subsp. *thermophilus* (9.20%), *Lactobacillus casei* subsp. *casei* (5.80%) and *Lactobacillus plantarum* (5%) [15]. A bacterial strain *Enterococcus hirae* (MTCC 10507) was isolated from camel milk by Madhu

E-mail address: shori_7506@hotmail.com.

http://dx.doi.org/10.1016/j.phanu.2017.06.003
Received 31 May 2017; Accepted 23 June 2017
Available online 24 June 2017

Table 1
Isolation and identification of potential probiotic strains and novel food cultures from camel milk and its fermented products.

Species	Sample type/source	pH	Media	Incubation condition	Temperature	Duration (h)	Number (%) of isolates obtained from media	Geographical area	References
Enterococcus casseliflavus /Enterococcus gallinarum	Milk container surface samples (n = 8)	ND	MRS	Anaerobically	37 °C	48	2 (25.0%)	East African	[14]
Enterococcus casseliflavus	Raw milk (n = 30)	ND	M17	Aerobically	45 °C	48	9 (7.5%)	Morocco	[15]
Enterococcus faecalis	Pooled milk (n = 5)	6.5 ± 0.1	M17	Aerobically	30 °C	24	2 (11.8%)	East African	[14]
	Local collection point (n = 5)	6.4 ± 0.2	M17	Aerobically	30 °C	24	1 (50.0%)		
			KFS	Aerobically	43 °C	48	3 (50.0%)		
	Final market (n = 4)	6.2 ± 0	KFS	Aerobically	43 °C	48	6 (100.0%)		
	Milk container surface samples (n = 8)	ND	KFS	Aerobically	43 °C	48	6 (60.0%)		
	Suusac (n = 24)	4.9 ± 0.9	M17	Aerobically	30 °C	24	1 (1.0%)		
			KFS						
				Aerobically	43 °C	48	3 (2.2%)		
	Raw milk (n = 30)	ND	M17	Aerobically	45 °C	48	4 (3.3)	Morocco	[15]
	Raw camel milk and shubat (n = 26)	ND	MRS	n	37 °C	48	n	Kazakhstan	[16]
			M17						
	Shubat (n = 7)	3.7–4.1	MRS	Aerobically	37 °C	48	3(5%)	Saudi Arabia	[17]
Enterococcus faecium	Gariss (n = 9)	3.79–4.43	MRS	Anaerobically	37 °C	48	5(7–36%)	Sudan	[9]
	Raw camel milk and shubat (n = 26)	ND	MRS	n	37 °C	48	n	Kazakhstan	[16]
			M17						
	Raw milk (n = 10)	ND	MRS	Anaerobically	20 °C	48	n (99%)	Iran	[18]
	Shubat (n = 5)	ND	MRS	Aerobically	30 °C	48	n	Kazakhstan	[19]
	Shubat (n = 7)	3.7–4.1	MRS	Aerobically	37 °C	48	5(14%)	Saudi Arabia	[17]
Enterococcus durans	Raw milk (n = 21)	ND	MRS	Anaerobically	37 °C	48	1 (9%)	Egypt	[20]
	Raw camel milk and shubat (n = 26)	ND	MRS	n	37 °C	48	n	Kazakhstan	[16]
			M17						
	Shubat (n = 5)	ND	MRS	Aerobically	30 °C	48	n	Kazakhstan	[19]
	Raw milk (n = 10)	ND	MRS	Anaerobically	20 °C	48	n (99%)	Iran	[18]
Enterococcus lactis	Raw milk (n = 10)	ND	MRS	Anaerobically	20 °C	48	n (98%)	Iran	[18]
Lactobacillus spp.	Suusac (n = 24)	4.9 ± 0.9	MRS	Anaerobically	37 °C	48	1 (0.7%)	East African	[14]
Lactobacillus casei subsp. casei	Raw milk (n = 30)	ND	MRS	Aerobically	30 °C	24–48	7 (5.8%)	Morocco	[15]
	Raw camel milk and shubat (n = 26)	ND	MRS	n	37 °C	48	n	Kazakhstan	[16]
			M17						
Lactbacillus casei	Gariss (n = 24)	3.41–3.82	MRS	n	n	n	4(3–7%)	Sudan	[21]
	Raw camel milk and shubat (n = 26)	ND	MRS	n	37 °C	48	n	Kazakhstan	[16]
			M17						
	Raw milk (n = 10)	ND	MRS	Anaerobically	20 °C	48	n (98%)	Iran	[18]
	Raw milk (n = 8)	ND	MRS	Aerobically	30 °C	48	n	Kazakhstan	[19]
	Shubat (n = 7)	3.7–4.1	MRS	Aerobically	37 °C	48	6(26%)	Saudi Arabia	[17]
Lactobacillus casei subsp. rhamnosus	Raw milk (n = 30)	ND	MRS	Aerobically	30 °C	24–48	1 (0.8%)	Morocco	[15]
Lactobacillus plantarum	Raw milk (n = 30)	ND	MRS	Aerobically	30 °C	24–48	6 (5%)	Morocco	[15]
	Raw milk (n = 21)	ND	MRS	Anaerobically	37 °C	48	1 (9%)	Egypt	[20]
	Suusac (n = 15)	3.6–4.4	MRS	Anaerobically	30 °C	72	n(16%)	Kenya	[22]
	Gariss (n = 12)	ND	MRS	Anaerobically	30 °C	72	n(29.17%)	Sudan	[23]
	Gariss (n = 24)	3.41–3.82	MRS	n	n	n	8(3- 35%)	Sudan	[21]
	Sour milk (Chal; n = 9)	ND	MRS	n	37 °C	48	64 (13%)	Iran	[24]
	Raw milk (n = 80)	ND	MRS	Anaerobically	37 °C	48	6 (n)	Tunisia	[25]
Lactobacillus fermentum	Suusac (n = 24)	4.9 ± 0.9	MRS	Anaerobically	37 °C	48	4 (2.9%)	East African	[14]
	Gariss (n = 9)	3.79–4.43	MRS	Anaerobically	37 °C	48	9(23–89%)	Sudan	[9]
	Gariss (n = 24)	3.41–3.8	MRS	n	n	n	3(2–7%)	Sudan	[21]
	Gariss (n = 12)	ND	MRS	Anaerobically	30 °C	72	n(4.17%)	Sudan	[23]
	Raw milk (n = 80)	ND	MRS	Anaerobically	37 °C	48	14 (n)	Tunisia	[25]

(continued on next page)