ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Effect of Using Cereals on the Quality of Fermented Camels' Milk Products.

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ABSTRACT

The possibility of producing functional fermented camels' milk products from pastes of some cereals (barley, oat, rice and wheat), using CH-1(Lactobacillus delbrueckii ssp. bulgaricus and Streptococcus thermophilus) and AB-sweet (Lactobacillus acidophilus and bifidobacteria) as yoghurt and probiotic starters, respectively were studied. Physicochemical, sensory properties and surviving starter microorganisms were followed in cereal-based fermented camels' milk products during storage period (9 days at 6±0.5 °C). The effect of type of cereal on the chemical composition of the resultant products was more pronounce than that of type starter used. Fermented camels' milk (FCM) products containing barley and wheat characterized by higher moisture, fat and total protein % and whey separation values than those containing of oats and rice. The highest crude fiber and ash %, acetaldehyde and diacetyle amounts, dynamic viscosity values and bacterial strain counts were detected in FCM containing of barley and oats. Also, the highest total carbohydrate % and pH values were observed in FCM containing of wheat and rice. Cereal-based camels' milk products fermented with CH-1 showed lower amounts of acetaldehyde and diacetyle, dynamic viscosity and pH values, but higher amounts of whey separation than that with AB-sweet. The viable cells counts in all cereal- based FCM products were maintained at an acceptable level until the end of storage period. Among different treatments, FCM made with rice was rated the highest score in the organoleptic properties especially when fermented with AB-sweet followed by their containing of wheat. Therefore, the development of cereal-based FCM can be considered as new products with nutritional and functional values as well as good organoleptic properties could be produced using yoghurt and probiotic starters.

Keywords: Cereal-based fermented camels' milk products, yoghurt and probiotic starters physicochemical, bacteriological, organoleptic properties.

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INTRODUCTION

Fermentation is one of the oldest and most economical methods of producing and preserving food [1, 2]. Fermentation is carried out to enhance flavour, aroma, shelf-life, texture, nutritional value and other pleasant and appealing properties of foods [3,4].The flavour and taste of acid-fermented products are believed to be produced mainly by organic acids together with free amino acids and carbonyl compounds such as acetaldehyde and diacetyl [5,6,7,8]. Fermented products are produced world-wide using various manufacturing techniques, raw materials and microorganisms [9, 10, and 11]. Fermented milk products are widely consumed for their benefits and refreshing effects. Their popularity is said to be attributed to the effective use of consumer driven flavours and milder cultures [12]. These products already have a positive health image [13, 14], which can be further enhanced by the addition of probiotic bacteria with therapeutic properties [15].

The use of milk with particular nutritional properties such as camel milk, in combination with bacterial strains having probiotic properties and/or producing physiologically active metabolites, represents one of the technology options for manufacturing dairy functional products. Camel milk and its products are a good nutritional source for human diet in several parts of the world as they contain all essential nutrients [16]. It is well known that, camel milk has potential therapeutic properties, such as anticarcinogenic [17], antidiabetic [18], antihypertensive [19], and has been recommended to be consumed by children who are allergic to bovine milk [20]. Camel milk is somehow different from cow milk in its chemical composition but it contains all essential nutrients as cow milk, also its high whey proteins such as lactoferrin which present in large quantities in camel milk (ten times higher than in cow milk) does have some anti-viral, anti-bacterial properties and immunoglobulin confer to it the high antimicrobial properties [21, 22]. Furthermore, camel milk has greater contents of vitamin C, ash, sodium, potassium, phosphorus, zinc, iron (10 times as rich in iron as cow's milk) and manganese than cow’s milk [23]. Camel milk has positive effects in controlling high blood pressure and helps in the management of arteriosclerosis and osteoporosis. Also, camel milk contains high insulin and insulin-like protein, which can help in regulating the blood glucose levels in the diabetic patients. [24, 25]. Moreover, camel milk lacks β-lactoglobulin and contains α-lactalbumin, a similar situation to that in human milk. Previous research has recommended the potential use of camel milk in the manufacture of infant formula [26]. Products made from camel milk include the traditionally fermented products garris and koumiss, Domiati cheese, fresh soft white cheese, hard cheese, and ice-cream [23]. The consumption of camel’s milk, especially in fermented form, is a very old tradition in different regions of the world such as Africa and Middle Eastern countries [27]. The nutritional properties, aroma and flavour of camel milk can be improved by fermentation. Fermented camel milk has been shown to be effective against pathogens (therapeutic properties) including Bacillus, Staphylococcus, Salmonella and Escherichia [25].

During the last decade, fundamental studies opened a new field of research dealing with the health promoting, disease prevention by incorporation of probiotic bacteria into foods to counteract harmful bacteria in the intestinal tract so-called functional foods [28]. The concept of functional foods includes foods for food ingredients that exert a beneficial effect on host health and/or reduce the risk of chronic disease beyond basic nutritional functions [29]. The interest in developing functional foods is thriving largely by the market potential for foods that can improve the health and well being of consumers [30, 31, 32]. In this respect, the functional food research has moved progressively toward the development of dietary supplementation, introducing the concept of probiotics and prebiotics, which may affect gut microbial composition and activities [33]. From this concept, cereals offer another alternative for the production of functional foods.

Cereals are one of the most suitable substrates for the development of foods containing probiotic microorganisms (in most cases lactic acid bacteria or bifidobacteria) [34,35] and may also have prebiotic properties due to the presence of non-digestible components of cereal matrix. During cereal fermentations several volatile compounds are formed which contribute to a complex blend of flavours [2]. The presence of aromas such as diacetyl, acetic acid and butyric acid make fermented cereal based products more appealing [4].

Cereals are grown over 73% of the total world harvested area and contribute over 60 % of the world food production providing dietary fiber, proteins, energy, minerals, and vitamins required for human health. Cereals belong to the most important food for the majority of mankind. They are a good source of saccharides (especially starch), fibers, lipids (essential fatty acids, almost no presence of saturated fatty acids), vitamins (B group), and minerals (calcium, potassium, magnesium, iron, zinc, cuprum, and phosphorus) [4,36,37,38] and phytochemicals with antioxidant properties [39,40,41].On the other side cereals are limited essential amino acids such as threonine, lysine and tryptopan, thus making their protein quality poorer compared with animals and milk [2]. Their protein digestibility is also lower than that of animals due partially to the presence of anti-nutritive factors such as phytic acids, tannins, and polyphenols which bind to protein thus making them indigestible [42]. Nowadays, cereals alone or mixed with other ingredients are used for the production of traditional fermented beverages as well as for the development of new foods with enhanced healthy properties using probiotic strain for fermentation process [4]. Cereal food industry has demonstrated their speed in exploiting these changes in food consumption model, and the large variety of cereals products existing nowadays is eloquent. The possible applications of cereal constituents in functional food applications could be summarized: a-as fermentable substrates for growth of probiotics microorganisms, especially lactobacillus and bifidobacterium; b-as dietary fiber promoting several beneficial physiological effects; c-as prebiotics due to their content of specific non digestible carbohydrates and d- as encapsulation materials for probiotics in order to enhance their stability [30]. However, the nutritional quality of the cereals and the sensorial properties of their products are sometimes inferior or poor in comparison with milk and milk products. Fermentation may be the most simple and economical way of improving their nutritional values, sensory properties and functional qualities [4].

Lactic acid fermentation of cereals is a long established processing method and is being used in Asia and Africa for the production of foods in various forms. The good growth of lactic acid bacteria (LAB) in cereals suggests that the incorporation of a human derived `probiotic strain in a cereal substrate under controlled conditions would produce a fermented food with defined and consistent characteristics, and possibly health promoting properties combining the probiotic and prebiotic concept. Lactic acid fermentation of different cereals has been found effectively to reduce the amount of phytic acid, tannins and improve protein availability [5]. Increased amounts of riboflavin, thiamine, niacin, and lysine due to the action of LAB in fermented blends of cereals were also reported [43]. Lactic acid fermentation improves the sensorial values, which is very much dependent on the amounts of lactic acids, acetic acid and several aromatic volatiles such as higher alcohols, aldehydes, ethyl acetate and diacetyle, produced via the homofermentative or heterofermentative metabolic pathways [44]

Numbers of fermented products based on milk or curd have been prepared by using probiotic micro-organism, but until now, much less work has been done on the development of probiotic fermented products based on cereals. Cereals and milk are predominantly fermented by the LAB [6]. To the best of our knowledge, no studies have previously considered the combined use of cereals and camel milk for the manufacture of novel fermented product. Consequently, the current focus is on the manufacture of fermented camel milk product with new ingredients (cereals), having high functionality and acceptability or by another word using cereals for the development of a functional camels' milk products. In this context, the aim of this paper was to investigate the production process and properties of fermented cereal-based functional camel’s milk products using pastes made from barley, oat, rice and wheat grains using commercial yoghurt and probiotic starter cultures for enhancing nutritional and functional values of these products with the emphasize on the physicochemical properties and sensory quality attributes during storage.

MATERIALS AND METHODS

Materials

Camels’ milk batches were obtained from the herd raised in Ras Sudr Research Station, Desert Research Center, South Sinai Governorate. All animals were kept under the same conditions. Bulk camels’ milk samples were analyzed for chemical composition and divided into 4 lots for manufacturing subsequent fermented cereal-based treatments. The approximate composition of used camels’ milk is shown in **Table (1).** Four different commercial cereals namely; barely (*Hordeum* spp) , oat (*Avena* spp) , rice (*Oryza* spp) and wheat (*Triticum* spp), were obtained from Plant Breeding Unit, Plant Genetic Resources, Desert Research Center, Cairo, Egypt. Two commercial freeze-dried DVS mixed bacterial starters of CH-1(containing of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*) as yoghurt starter and AB- sweet (containing of *Lactobacillus acidophilus* and bifidobacteria) with potential probiotic properties starters (from Chr. Hansen Laboratory Copenhagen, Denmark) were used in the fermentation process. Freeze-dried bacterial starters used in the fermentation process were prepared separately as mother cultures in autoclaved (121°C/10 min) fresh buffaloes' skim milk (0.1 % fat and 9.5% SNF) using a 0.02 % (w/v) inoculums. The cultures were incubated at 40°C for CH-1starter and 37°C for AB- sweet starter, until curdling of milk. Cultures were prepared 24h before use.

Table 1: Chemical composition (Mean± Standard deviation) of fresh camels' milk used for manufacture cereal-based fermented camels' milk

Sample	pH	Chemical composition (%)				
		Fat	Protein	Ash	Total carbohydrates	Total Solid
Bulk camels' milk	6.7±0.05	3.82±0.04	3.56 ±0.03	0.85±0.007	4.33±0.08	12.56±0.11

Protein%= T.N %× 6.38; Total carbohydrates %: Calculated by the difference

Table 2: Chemical composition (Mean± Standard deviation) of different cereal's pastes used in the manufacture of cereal-based fermented camels' milk

Chemical composition (%)	Cereal pastes			
	Barely	Oat	Rice	Wheat
Moisture	73.57±0.28	76.73±0.35	73.32±0.11	69.11±0.40
Fat	0.64±0.01	1.04±0.05	0.17±002	0.52±0.01
Total protein	3.68[1]±0.08	3.13[1]±0.10	2.12[2]±0.06	3.73[3]±0.09
Total carbohydrates *	19.68±0.14	15.01±0.09	24.24±0.18	25.44±0.13
Crude fiber	1.74±0.06	3.21±0.08	0.32±0.02	0.73±0.02
Ash	0.87±0.02	0.96±0.03	0.28±0.01	0.62±0.02

*Calculated by the difference; [1]Total protein (%) = N×5.36 ; [2]protein (%) = N×5.17 ; [3]protein (%) = N×5.33

Table 3: Composition (kg/6kg blend) of different cereal's blend used in the manufacture of cereal-based fermented camels' milk

Ingredients	Blends			
	Barely	Oat	Rice	Wheat
Bulk camels' milk	3.083	2.244	3.177	3.865
Barely paste	2.917	-	-	-
Oat paste	-	3.756		-
Rice paste	-	-	2.823	-
Wheat paste	-	-	-	2.135
Total	6	6	6	6

Methods

Manufacture of cereal-based fermented camels' milk

Four dry cereals were prepared following the same procedure. Cereals were putted; individually; in a pan with tap water, bring it to a boil; then simmer until the liquid was absorbed and become soft. The resultant cooked cereals were converted into pastes using National automatic mixer (Matsushita Electric Industrial Company Ltd, Tokyo, Japan). Camels' milk was mixed with different cereal's pastes to contain final blends with approximately 20% total solids. Chemical composition of different cereal's pastes used in the manufacture of cereal-based fermented camels' milk is presented in **Table 2**. Composition (kg/6kg blend) of different cereal's blend used in the manufacture of cereal-based functional fermented camels' milk is presented in **Table 3**. All cereals blends were heated in a water bath to 85°C/30min, then each type of blend was divided into two portions. The first one was cooled to 40°C and the second to 37°C for inoculation with 2% (v/v) of CH-1 and AB- sweet mother cultures, respectively. The different treatments were poured into 150 cc plastic cups and incubated to ~ 3 h for CH-1culture and ~ 4 h for AB-sweet culture, then immediately cooled and stored for 9 days at 6±0.5°C. The final fermented cereal-based camels' milk products were analyzed to physicochemical (zero day), microbiological, dynamic viscosity, pH values and organoleptic properties throughout storage (zero, 3, 6 and 9) days at 6±0.5°C.

Chemical and physicochemical analysis

Cereal pastes was analysed for moisture content (by dry oven method), fat (using Soxhlet method), total nitrogen (using micro-Kjeldahel method); crude fiber and ash (using Thermolyne, type 1500 Muffle Furnace) contents according to the methods described by [45]. Camels' milk and cereal-based functional fermented camels' milk were analysed for total solids and moisture content (by dry oven method) , fat (using Gerber method), total nitrogen (using micro-Kjeldahel method); and ash (using Thermolyne,type 1500 Muffle Furnace) contents ; as well as pH values (using digital pH meter, Inolad model 720, Germany) according to [46]. Total carbohydrates were calculated by the difference for all samples analysed. Synersis was measured as described by [47], as the amount of spontaneous whey (ml /100g) drained off after 2 h at 7°C. Acetaldehyde and diacetyl (µmol/ml) contents were determined according to [48, 49], respectively. Viscosity was measured using a Brook field digital viscometer (Brookfield Engineering Laboratory Inc., Stoughton, MA) Model DV- II with a helipath stand mounted with a spindle size-00, that rotated at different rpm ranged from (30-100) at shear rates ranging from 77.67 to 464.77 s^{-1}. Data were collected Using Wingather soft ware (Brookfield Engineering Laboratory Inc., Stoughton, MA). Shear stress values (dyne/cm^2) was recorded at 22 $\pm 1^{o}C$ during storage period (zero time and after 3, 6 and 9 days) for all samples, as formerly described by [50].

Bacteriological analysis

Samples of all cereal-based functional fermented camels' milk were prepared for bacteriological analysis according to the method described in the Standard Methods for the Examination of Dairy Products [51]. Viable counts of *Lactobacillus delbrueckii* ssp. *bulgaricus* on MRS agar (pH 5.2)(Anaerobic incubation at $45^{\circ}C$ for 72h), *Lactobacillus acidophilus* on MRS-sorbitol agar (Anaerobic incubation at $37^{\circ}C$ for 72h), *Streptococcus thermophilus* on ST agar (Aerobic incubation at $37^{\circ}C$ for 24h) and bifidobacteria on MRS agar (Oxoid) supplemented with L-cystein and lithium chloride (Sigma Chemical CO., USA) (Anaerobic incubation at $37^{\circ}C$ for 72h) were enumerated as described by [52]. The plates were incubated in an anaerobic environment (BBLGas Pak, Becton Dickinson Microbiology Systems). The results expressed as log colony forming unit ($\log_{10}$ cfu)/ml of sample.

Sensory evaluation

Cereal-based functional fermented camels' milk samples were subjected to sensory analysis by 20 panelists of the staff member of Animal Production Division, Desert Research Center, Cairo, Egypt according to the scheme described by [53]. All tratmants were evaluated when fresh (one day) and throughout storage for 9 days at $6\pm0.5^{\circ}C$. The sensory attributes evaluated were: flavour (1-10points), body and texture (1-5 points) and appearance and colour (1-5points).

Statistical analyses

All experiments and analysis were done in triplicate. Statistical analyses were carried out using the General Liner Models procedure of the SPSS 16.0 Syntax Reference Guide [54]. The results were expressed as least squares means with standard errors of the mean. Statistically different groups were determined by the LSD (least significant difference) test ($p \le 0.05$).

RESULTS AND DISCUSSION

Physico chemical properties of fresh cereal-based functional fermented camels' milk

Physicochemical properties of fresh (after 24 h of refrigerated storage) cereal-based functional fermented camels' milk products are presented in **Table (4).** The results revealed that, the effect of type of cereal on the chemical composition of the resultant products was more pronounced ($p\le0.05$) than that of type of starter culture used ($p\ge0.05$). Moreover, there were no significant differences ($p\ge0.05$) found in the fat, total carbohydrate, crude fiber and ash contents, but significant ($p\le0.05$) in the moisture and total protein contents between different cereal-based functional fermented camels' milk products, depending on the type of starter culture. The cereal-based camels' milk treatments fermented with yoghurt starter (CH-1) culture showed slight increase in the total carbohydrate and total protein contents, but decrease in moisture content than that of treatments fermented with probiotic starter (AB-sweet) culture. Among treatments, the cereal-based functional fermented camels' milk containing of wheat were characterized with the highest contents of moisture, fat and total protein. While, the cereal- based functional fermented camels' milk containing of rice were characterized with the lowest contents of moisture, fat and total protein. Moreover, the cereal-based functional fermented camels' milk treatments containing of oat were characterized with the highest contents of crude fiber and ash. These differences in the chemical properties of cereal-based functional fermented camels' milk tratments could be due to the chemical composition of the original cereal pastes and cereal blends (Tables 2&3). These results were in agreement with those obtained by [55], who stated that, the type of culture used in the fermentation didn't affect on the total solids, total protein, fat and total carbohydrate contents of yoghurt , Bioghurt and Bifighurt. Also, it could be observed from the date that, cereal-based functional fermented camels' milk treatments with AB-sweet showed slight decreased in total protein content than that made by use yoghurt starter culture (CH-1); this may be due to the limited proteolysis of milk protein by lactic acid bacteria, same findings reported by [56]. The cereal-based functional fermented camels' milk containing barely and wheat showed higher spontaneous syneresis (ml/100g) than that containing of oat and rice **(Table 4).** The type of cereal in side and starter culture used in the fermentation on the other side significantly affected ($p \leq 0.05$) on the syneresis amounts. Also, cereal-based fermented camels' milk with CH-1culture had higher amounts of whey separation than that with AB-sweet culture. [57, 58] stated that, some strains of lactic acid bacteria used in the manufacture fermented milk products produced exopolysaccharides, which affect syneresis of fermented products. Also, exopolysaccharides have the ability to bind water and reduce whey syneresis [59].

Table 4: Physicochemical properties of fresh cereal-based fermented camels' milk

Physicochemical properties	Type of starter	Type of cereals			
		Barely	Oat	Rice	Wheat
Fat%	CH-1*	1.91^{Aa}±0.02	1.74^{Ba}±0.01	1.61^{Ca}±0.03	1.96^{Aa}±0.02
	AB-sweet**	1.91^{Aa}±0.05	1.74^{Ba} ±0.01	1.60^{Ca} ±0.04	1.95^{Aa} ±0.03
Total protein (N×6.38)	CH-1	4.08^{ABa} ±0.07	3.59^{Bb} ±0.09	3.49^{BCc} ±0.18	4.15^{Aa}±0.11
	AB-sweet	4.03^{ABa} ±0.05	3.53^{Bb} ±0.12	3.47^{BCc} ±0.09	4.11^{Aa} ±0.014
Total carbohydrate [1]%	CH-1	13.59^{BCbc} ±0.20	13.09^{Cc} ±0.14	16.09^{Aa} ±0.26	14.04^{Bb} ±0.18
	AB-sweet	13.56^{BCbc} ±0.11	13.07^{Cc} ±0.19	16.06^{Aa} ±0.22	14.02^{Bb} ±0.16
Ash%	CH-1	0.91^{Aa} ±0.01	1.02^{Aa} ±0.02	0.56^{Cc}±0.04	0.72^{Bb} ±0.02
	AB-sweet	0.91^{Aa} ±0.03	1.02^{Aa} ±0.02	0.56^{Cc}±0.03	0.72^{Bb} ±0.01
Crude fiber%	CH-1	0.96^{Bb} ±0.01	2.36^{Aa} ±0.02	0.14^{Dd}±0.01	0.30^{Cc} ±0.01
	AB-sweet	0.96^{Bb} ±0.01	2.36^{Aa} ±0.05	0.14^{Dd} ±0.01	0.30^{Cc} ±0.02
Moisture%	CH-1	78.55^{Aa} ±0.85	78.21^{ABa} ±1.02	78.12^{Bb}±0.92	78.83^{Aa} ±1.23
	AB-sweet	78.63^{Aa} ±1.08	78.28^{ABa} ±1.19	78.14^{Bb}±0.85	78.88^{Aa} ±1.07
Spontaneous syneresis(ml/100g)	CH-1	18.50^{Bb} ±0.30	15.80^{Cc} ±0.26	13.50^{Dd}±0.29	24.60^{Aa} ±0.25
	AB-sweet	17.20^{Bb} ±0.22	14.50^{Cc} ±0.24	11.20^{Dd} ±0.28	23.30^{Aa} ±0.19
Diacetyle (µmol/ml)	CH-1	27.90^{Aa} ±0.28	25.30^{Bb} ±0.35	22.60^{Dd} ±0.36	23.70^{Cc} ±0.16
	AB-sweet	30.30^{Aa} ±0.21	28.10^{Bb} ±0.27	25.20^{Dd} ±0.20	26.10^{Cc} ±0.27
Acetaldehyde (µmol/ml)	CH-1	339.40^{Aa} ±1.42	333.20^{Bb} ±1.16	319.90^{Cc} ±1.03	322.80^{Dd} ±1.24
	AB-sweet	355.60^{Aa} ±1.11	340.60^{Bb} ±0.98	323.90^{Cc} ±1.28	329.90^{Dd} ±1.16

[1] : Calculated by the difference.

*: Bacterial starter culture containing of *Lactobacillus delbrueckii ssp. bulgaricus* and *Streptococcus thermophilus* (as commercial yoghurt starter)

**: Bacterial starter culture containing of *Lactobacillus acidophilus* and bifidobacteria (with potential probiotic properties)

$^{A, B,C,\ldots}$: Means with the different capital $^{(A, B,\ldots)}$ superscript letters within the same raw indicate significant ($P \leq 0.05$) differences between Type of cereals and Type of starter

$^{a,b,c,\ldots}$: Means with the different small $^{(a, b,,,, ,\ldots)}$ superscript letters within the same column and property are significantly ($P \leq 0.05$) different between Type of cereals and Physicochemical properties

The changes in acetaldehyde and diacetyl contents are also shown in Table (4). Data reveled that, the acetaldehyde and diacetyl contents in cereal-based functional fermented camels' milk were significantly influenced ($p \leq 0.05$) by both the type of cereal and the starter used in the fermentation. The highest amounts of acetaldehyde and diacetyl were observed in fermented camels' milk containing of barley followed by that containing oat. On the other side, cereal-based treatments fermented with CH-1starter culture was characterized with the lower amounts of acetaldehyde and diacetyl than that with AB-sweet. [60] reported that, probiotic bacteria (*Lb. acidophilus*) used in fermented milk can form acetaldehyde from different courses such as carbohydrates, amino acids (such as threonine) and nucleic acids. Also, [61] reported that, *Lb. acidophilus* is of special interest for its stability to produce both acetaldehyde and diacetyl. The production of volatile compounds by the probiotic strain; *Lactobacillus plantarum* NCIMB 8826; in cereal-based media containing wheat, oat, barley and malt are depending more on the substrate than on the microorganism [62].

Table 5: Changes in pH values of different cereal-based fermented camels' milk products during storage at 6±1°C for 9 days

Type of cereals	Type of starter culture	Storage period (days)			
		zero	3	6	9
Barley	CH-1[*]	4.89^{Aa} ±0.05	4.83^{ABab} ±0.02	4.69^{BCbc} ±0.11	4.58^{Cc} ±0..03
	AB-sweet[**]	5.29^{Aa} ±0.07	5.18^{Aa} ±0.01	4.77^{BCbc} ±0.05	4.65^{Cc} ±0.09
Oat	CH-1	4.90^{Aa} ±0.03	4.88^{ABab} ±0.03	4.75^{BCbc} ±0.04	4.70^{Cc} ±0.02
	AB-sweet	5.31^{Aa} ±0.10	5.21^{Aa} ±0.07	4.83^{BCb} ±0.04	4.72^{Cc} ±0.06
Rice	CH-1	4.98^{Aa} ±0.06	4.94^{ABab} ±0.06	4.79^{Bbc} ±0.02	4.72^{Cc} ±0.07
	AB-sweet	5.34^{Aa} ±0.05	5.28^{Aa} ±0.06	$5.0\,3^{Bb}$ ±0.09	4.75^{Cc} ±0.05
Wheat	CH-1	4.93^{Aa} ±0.02	4.89^{ABab} ±0.05	4.74^{BCbc} ±0.03	4.65^{Cc} ±0.06
	AB-sweet	5.29^{Aa} ±0.06	5.21^{Aa} ±0.09	4.82^{BCb} ±0.08	4.73^{Cc} ±0.08

[*] : Bacterial starter culture containing of *Lactobacillus delbrueckii ssp. bulgaricus* and *Streptococcus thermophilus* (as commercial yoghurt starter)

[**] : Bacterial starter culture containing of *Lactobacillus acidophilus, Streptococcus thermophilus* and bifidobacteria (with potential probiotic properties)

$^{A, B, C,\ldots}$: Means with the different capital $^{(A, B,\ldots)}$ superscript letters within the same raw indicate significant (P≤0.05) differences between Storage period and Type of starter culture

$^{a,b,c,\ldots}$: Means with the different small $^{(a, b,\ldots)}$ superscript letters within the same column and property are significantly (P≤0.05) different between Storage period (days) and Type of cereals

From Table (5), it can be observed that, the pH values varied between different cereal-based functional fermented camels' milk products according to the type of cereal or starter culture used as well as time of the storage ($p \leq 0.05$). It could be noticed from the presented data that, the cereal- based functional fermented camels' milk containing of oat and barely were characterized with lower pH values as compared with their containing of rice and wheat either when fresh or during the cold storage period (6±1°C for 9 days). On the other side, cereal-based functional camels' milk products fermented with yoghurt starter (CH-1) culture was characterized with lower pH values during storage period, as compared with that made by probiotic starter (AB-sweet) culture. The higher acidity of cereal-based functional treatments made with CH-1starter could be attributed to the high activity of lactose in yoghurt starter splitting lactose into glucose and galactose as the first step of fermentation [63]. During the storage at6±1°C for 9 days, significant differences ($p \leq 0.05$) were recorded in pH values of all fermented cereal-based treatments. Moreover, a gradual decrease in pH values could be observed in all treatments with extending the storage period. This decrease could be attributed to a limited growth of different bacterial starter cultures and the slow fermentation of lactose residual. Same findings reported by [64]. Also, [65] mentioned that, minor differences were recorded in the lactose content between the fresh fermented milk products but variably decreased in all products during the storage.

Microbiological properties

Data presented in **Table (6)** indicated that, significant differences ($p \leq 0.05$) were found in log bacterial cell counts between different functional fermented cereal-based treatments as affected by the type of culture or cereal used and storage period (6±1°C for 9 days). Generally, the survival rate of *Str. thermophilus* was higher than that of *Lb. delbrueckii ssp. bulgaricus* in all cereal-based functional fermented camels' milk treatments either when fresh or during storage period. On the other hand, Bifidobacteria was exhibited the lowest levels of viable cells in all cereal-based functional fermented camels' milk products throughout the storage period. There were gradual increases in the viable cells counts detected until the 3rd day of storage, and then decreased. Survival of *Lb. bulgaricus*, *Str. thermophilus* , *Lb. acidophilus* and bifidobacteria cells during the storage period of all cereal-based fermented camels' milk treatments could be considered satisfactory until the 9 th day of storage period. The counts of viable cells in all cereal-based functional fermented camels' milk treatments were maintained at an acceptable level to be considered as functional foods until the end of cold storage period. This indicated that, the total numbers of bacterial starter strains in all cereal-based fermented camels' milk treatments were high enough to provide functional properties (10^6 cfu/ml), which is the recommended minimum daily intake as mentioned by [66]. The optimum final pH and the concentration of lactic acid and acetic acid in fermented cereal product in relation to the properties of each specific probiotic strain have to be investigated in order to maximize the viability during storage. For practical application; a pH value of the final product must be maintained above 4.6 to prevent the decline of bifidobacteria populations [67]. In addition, [68] suggested that, the cereal tested can produce LAB populations with higher cell concentrations than the minimum requirement for a probiotic drink (10^6 cfu/ml).

Table 6: **Viable cell counts ($\log_{10}$ cfu^1/ml) of bacterial starter strains in cereal-based functional fermented camels' milk products during storage at 6 ± 0.5˚C /9 days**

Type of starter / bacterial strains	Storage period (days)	Type of cereals			
		Barley	**Oats**	**Rice**	**Wheat**
		CH-1[*]			
Lb. bulgaricus	**0**	7.86^{Aab} ±0.16	7.89^{Aab} ±0.12	7.77^{Bc} ±0.09	7.81^{ABa} ±0.17
	3	7.90^{Bb}±0.09	7.96^{Aab}±0.15	7.90^{Bb} ±0.11	7.93^{ABa}±0.24
	6	7.82^{ABb} ±0.11	7.85^{Ab} ±0.10	7.72^{Bbc} ±0.27	7.78^{Bbc} ±0.18
	9	7.70^{Ab} ±0.15	7.73^{Abc} ±0.06	7.65^{ABbc} ±0.20	7.68^{ABbc} ±0.12
Str. thermophilus	**0**	8.71^{Aa} ±0.08	8.74^{Aa} ±0.22	8.62^{Ba} ± 0.15	8.66^{ABa} ±0.22
	3	8.73^{Aa} ±0.20	8.78^{Aa} ±0.19	8.65^{ABa} ±0.11	8.69^{ABa} ±0.14
	6	8.61^{AB} ±0.13	8.65^{Aa} ±0.16	8.54^{Ba} ±0.19	8.58^{ABa} ±0.18
	9	8.48^{ABa} ±0.11	8.52^{Aa} ±0.20	8.42^{Ba} ±0.22	8.46^{ABa} ±0.14
		AB-sweet**			
Lb. acidophilus	**0**	7.78^{Abc} ±0.25	7.81^{Aab} ±0.14	7.68^{Bc} ±0.17	7.73^{ABbc} ±0.20
	3	7.79^{ABbc} ±0.19	7.84^{Aab} ±0.11	7.72^{Bbc} ±0.14	7.77^{ABbc} ±0.18
	6	7.68^{ABc} ±0.17	7.73^{Abc} ±0.25	7.62^{Bc} ±0.20	7.65^{AB} ±0.13
	9	7.56^{Ac}±0.08	7.63^{Ac} ±0.14	7.48^{Bd} ±0.26	7.53^{AB} ±0.18
Bifidobacteria	**0**	7.74^{Abc} ±0.10	7.76^{Abc} ±0.18	7.66^{Bc} ±0.17	7.70^{AB} ±0.22
	3	7.75^{ABbc} ±0.22	7.78^{Abc} ±0.14	7.68^{Bc} ±0.19	7.73^{AB} ±0.15
	6	7.65^{Ac} ±0.16	7.69^{Ac} ±0.23	7.55^{Bcd} ±0.14	7.61^{ABc} ±0.19
	9	7.61^{Ac} ±0.12	7.65^{Ac} ±0.09	7.52^{Bd} ±0.20	7.57^{ABcd} ±0.14

Data represented average of 3 separate trials

1: Colony forming unit

*: Bacterial starter culture containing of *Lactobacillus delbrueckii ssp. bulgaricus* and *Streptococcus thermophilus* (as commercial yoghurt starter)

**: Bacterial starter culture containing of *Lactobacillus acidophilus* and bifidobacteria (with potential probiotic properties)

A, B,C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant (P≤0.05) differences between Storage period and Type of cereals

a,b,c,… : Means with the different small (a, b,,,, ,…) superscript letters within the same column and property are significantly (P≤0.05) different between Type of starter / bacterial strains and Type of cereals

Also, [69] mentioned that, the viable counts of all species except *B.bifidum* 2715 increased in the fermented camel milk during the first 3 days of storage at 4°C. Yoghurt culture of *Lb. bulgaricus* CH2 and *Str. Thermophilus* 37 (1:1) showed superior growth, acid production and proteolytic than single sturter cultures and acceptable fermented camel milk [70]. Moreover, [71] concluded that oat is in general a suitable substrate for LAB growth. Oat β-glucan has been reported to selectivity support the growth lactobacilli and bifidobacteria [72]. In addition, [73, 30] reported that the cereals can be used as fermentable substrates for the growth of probiotic microorganisms. Also, *Lb. acidophilus* exhibited the poorest growth in malt, barely and wheat media, probably because of substrate deficiency in specific nutrients.

Flow behaviour

The flow behaviour (shear stress/shear rate curves) of different cereal-based fermented camels' milk functional products during storage period at 6±1°C/9 days is depicted in figs. (1), (2), (3) and (4) when fresh, 3, 6 and 9 days, respectively .There were significant (p≤0.05) differences between shear stress values of cereal-based camels' milk products fermented with yoghurt (CH-1) or probiotic (AB-sweet) starter cultures in one side and type of cereal used (barely, oat, rice and wheat) on the other side. Also, there were significant ($p \leq 0.05$) differences in the dynamic viscosity values between different cereal-based fermented camels' milk products, depending on the type of cereal or starter culture used either when fresh and during storage period. During the investigated time of shearing, the dynamic viscosity values ($p \leq 0.05$) decreased as the shear rate increased in all treatments till the end of storage period, exhibited a pseudoplastic shear thinning behaviour. This shear thinning behavior is due to the progressive breakdown of aggregates formed between milk caseins by the action of the decrease in pH [74]. As it can be seen, the cereal-based functional fermented camels' milk containing of oat and barley were characterized with higher dynamic viscosity values during the investigated time of shearing and showed higher upward shifting of the flow curve, as compared with the other treatments containing of wheat and rice either when fresh (Fig.1) or at the end of storage period (Fig. 4). [75] demonstrated that, β-glucans are major components of starchy endosperm and aleurone cell walls of commercially important cereals such as; oat, barley, rye and wheat. These structural features appear to be important determinants of their physical properties such as; water solubility, viscosity and gelation properties. Among all the cereal grains, barely and oat contain the highest level of β-glucan. While, wheat is not recognized as a source of β-glucan because of its much lower content, below 1% on a dry basis [30]. Furthermore, as the storage period advanced the viscosity in all cereal-based fermented camels' milk increased gradually as shown in Fig. (4), it could be related to a strong protein network and firm curd. The same trend was founded in the stirred yoghurt by [76] who found that, the longer the storage time was, the higher the viscosity was, especially between day 1 and 7 days of cold storage. Also, [77, 78] reported that, viscosity is correlated with the firmness of yoghurt. These results are compatible with [79] who found that at constant shear rate, the apparent viscosity of Labneh increased with storage time. Similar observation was reported also by [80]. Concerning the type of starter used in the manufacture, using yoghurt starter (CH-1) in making cereal-based fermented camels' milk treatments was resulted in the downword shifting of the flow curve as compared with that made by probiotic starter (AB-sweet). This decrease in the flow curve indicated that, the dynamic viscosity values of cereal-based fermented camels' milk produced by CH-1culture were considerably less than that made with AB-sweet culture. Our result are in according with [30,81,75]. In addition, the increase in the viscosity values of fermented milk products could be due to some strains of LAB used in the manufacture produce EPS [81]. Also, [82] mentioned that, it is generally accepted that the viscosity of coagulum depends both on the amount of PS produced and on the pH.

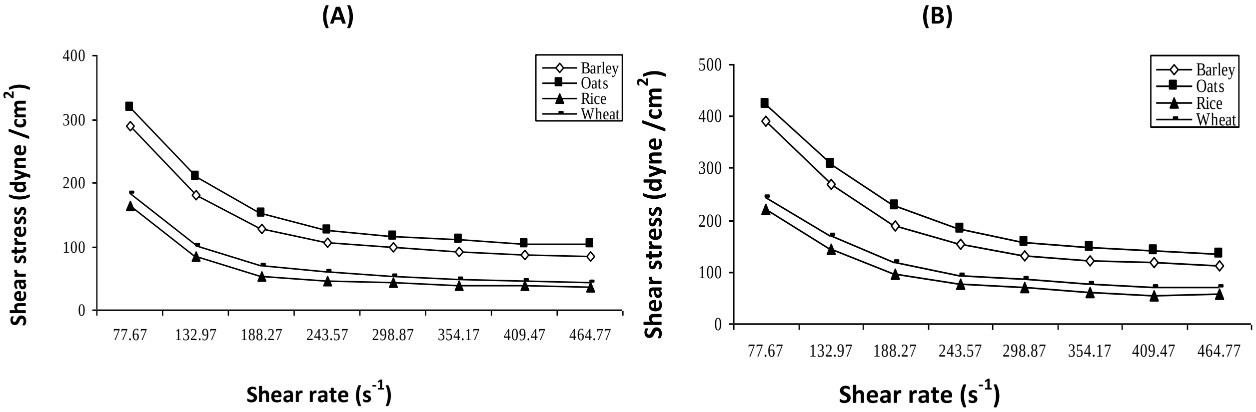

Fig.1. Flow behaviour of fresh cereal-based fermented camels' milk products fermented by yoghurt (A) and probiotic (B) starter cultures, respectively during the pickling period at 6±0.5°C/9 days.

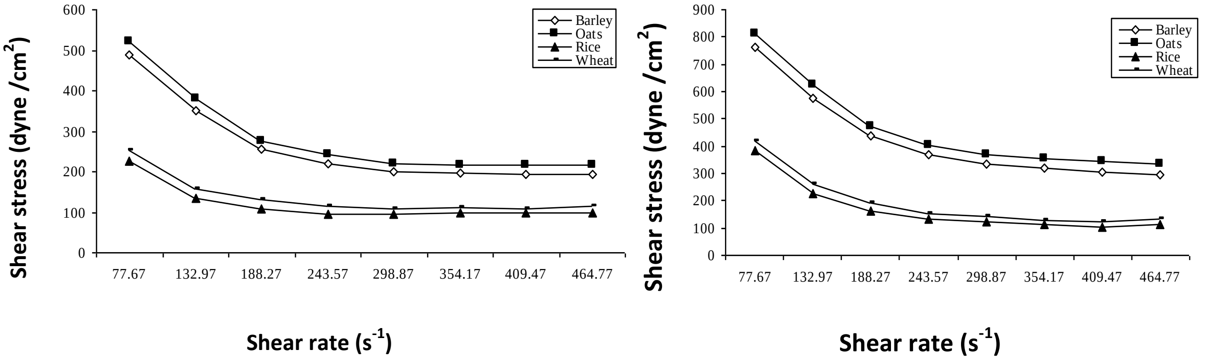

Fig.2. Flow behaviour of cereal-based fermented camels' milk products fermented by yoghurt (A) and probiotic (B) starter cultures, respectively during the pickling period at 6±0.5°C/3 days.

(A) **(B)**

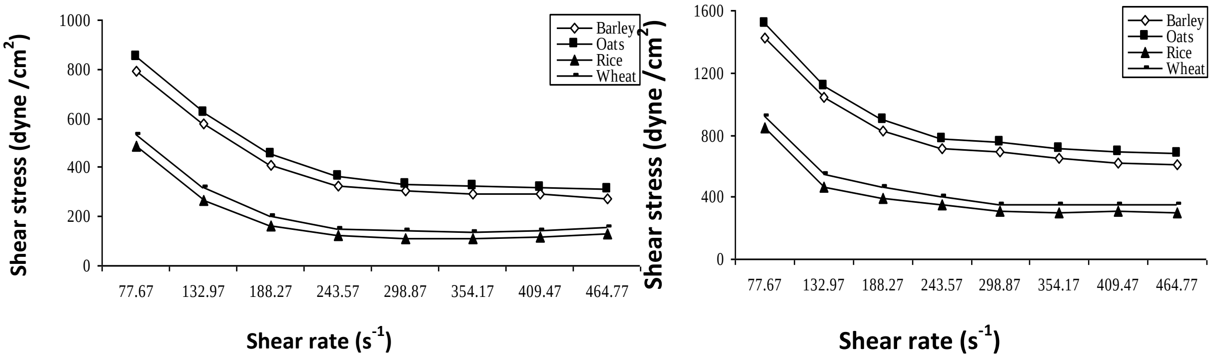

Fig.3. Flow behaviour of cereal-based fermented camels' milk products fermented by yoghurt (A) and probiotic (B) starter cultures, respectively during the pickling period at 6±0.5°C/6 days.

(A) **(B)**

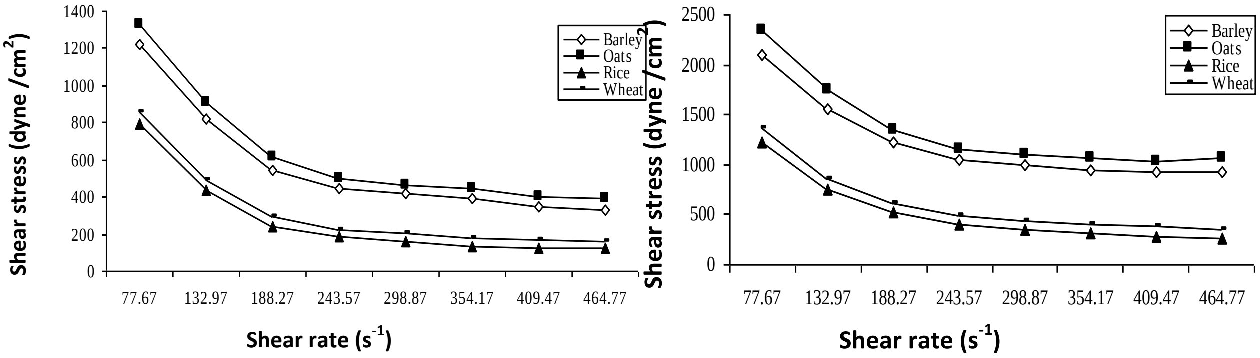

Fig.4. Flow behaviour of cereal-based fermented camels' milk products fermented by yoghurt (A) and probiotic (B) starter cultures, respectively during the pickling period at 6±0.5°C/9 days.

Organoleptic properties

The scores for organoleptic properties of fermented camels' milk functional products made from different cereals (barely, oat, rice and wheat) during storage at 6±0.5°C for 9 days are presented in Table (7). All cereal-based fermented camels' milk treatments were acceptable with significant differences ($p \leq 0.05$) among each other, where the type of cereal and starter used in the fermentation process, as well as time of the storage were the principle factors ($p \leq 0.05$) influencing on the organoleptic properties. It is clear that no marked change occurred in colour and appearance either in fresh or in stored treatments. More over, all treatments characterized by specific taste which is due to the type of cereal used. The resultant products had a good general appearance, body and texture (soft, smooth and lubricity texture) and pleasant creamy flavour. Among treatments, the cereal-based fermented camels' milk containing of rice rated the highest preference in the organoleptic properties either when fresh or during storage and were characterized with perfect flavour, body and texture, as well as whiteness appearance and color; especially when fermented with probiotic starter followed by their containing of wheat. On the other side, cereal-based fermented camels' milk containing of barely ranked the lowest organoleptic scores throughout the storage period (6±0.5°C for 9 days), possible explanation could be due to the pronounced of malt flavour , light brown colour and small amount of free whey; especially when probiotic culture used in the fermentation process. Concerning the type of starter used, the cereal based fermented camel's milk with yoghurt culture ranked lower flavour scores that that fermented with probiotic culture; it could be due to the light acidic flavour and gel-like body and texture than that with probiotic culture (light sweetie flavour and ropy body and texture). While, whiteness appearance and colour were detected in cereal-based fermented camel's milk with yoghurt culture compared with probiotic culture. Additionally, the total quality of the final cereal-based functional fermented camels' milk products were significantly decreased ($p \leq 0.05$) with extending the storage period 6±0.5°C for 9 days. The decrease in quality (flavour, body and texture and appearance) started to be seen after the 6th day of storage and all treatments scored the lowest at the 9th day of storage period. This may be contributed to the high content of several volatile compounds during the fermentation of cereal serve as a precursor of certain flavour compounds, which contribute to a complex blend of flavours in the product. Same findings recorded by [2, 4]. The decrease in total quality during storage was more marked in cereal- based treatments containing of barely. While, treatments of rice possessed the highest score until the end of storage period followed by wheat and oat. Also, the whey separation in white color appeared to be decreased during storage in all treatments (Table, 7). [83] mentioned that, during storage of cereal based low fat fruit yoghurt, acidic or malt flavour, firm or ropy body and texture, shrunken or free whey appearance, as well as light brown colour were increased in different cereal-based fermented milk products at the end of storage. Moreover, the presence of aromas representative of diacetyl, acetic acid and butyric acid make fermented cereal-based products more appetizing. Also, [62] found that, inoculation with the probiotic lactic acid bacteria caused a significant change in the aroma profile of the four cereal broths. The oat medium showed a significant increment in the contents of flavour active volatiles. In barely, considerable amounts of new volatiles were generated after the fermentation. In general, the volatile production depends more on the substrate than on the microorganism. Also, [61] mentioned that *Lb.acidophilus* La5, *Lb.acidophilus* 1748 and *B.animalis* BB12 produced acetaldehyde in amounts that would have an influence on the sensory profile of the product.

Table 7: Sensory evaluation scores of cereal-based fermented camels' milk products during storage at 6 ± 0.5°C /9 days

Type of starter / parameters	Storage period (days)	Type of cereals			
		Barley	Oats	Rice	Wheat
CH-1*					
Flavour (1-10 points)	0	6.52^{Ad} ±0.12	8.41^{Bb}±0.16	9.54^{Aa}±0.10	9.48^{ABa} ±0.17
	3	6.09^{Cde}±0.17	8.22^{ABb} ±0.09	9.30^{Aa} ±0.13	9.26^{Aa} ±0.12
	6	5.55^{Ce} ±0.10	7.93^{Bc} ±0.06	9.12^{Aa} ±0.11	9.08^{Aab} ±0.18
	9	4.49^{Ce} ±0.11	7.49^{Bcd} ±0.10	8.78^{Ab} ±0.18	8.65^{Ab} ±0.14
Body & Texture (1-5 points)	0	3.61^{Cf} ±0.07	4.42^{BCe} ±0.05	4.52^{Ae} ±0.06	4.58^{Ae} ±0.06
	3	3.44^{Cf} ±0.08	4.26^{Be} ±0.07	4.40^{Ae} ±0.08	4.45^{Ae} ±0.04
	6	3.28^{Af} ±0.11	4.17^{Be} ±0.06	4.23^{Ae} ±0.05	4.27^{Ae} ±0.09
	9	2.98^{C} ±0.09	3.85^{Bf} ±0.05	3.98^{A} ±0.10	4.05^{Aef} ±0.03
Appearance &colour (1-5 points)	0	3.24^{Cf} ±0.04	4.76^{Be} ±0.09	4.92^{Ae} ±0.11	4.85^{ABe} ±0.10
	3	3.16^{Cf} ±0.13	4.61^{Be} ±0.04	4.81^{Ae} ±0.08	4.72^{ABe} ±0.05
	6	2.99^{Cfg} ±0.05	4.48^{Be} ±0.11	4.64^{Ae} ±0.014	4.56^{ABe} ±0.08
	9	2.65^{Cg} ±0.03	4.20^{Be}±0.07	4.32^{A} ±0.06	4.27^{AB} ±0.09
AB-sweet**					
Flavour (1-10 points)	0	6.43^{Cd} ±0.10	8.47^{Bb} ±0.06	9.57^{Aa} ±0.15	9.52^{Aa} ±0.20
	3	6.05^{Cde} ±0.06	8.27^{Bb} ±0.03	9.34^{Aa} ±0.09	9.29^{Aa} ±0.18
	6	5.52^{Cde} ±0.11	7.96^{Bbc} ±0.08	9.15^{Aa} ±0.06	9.12^{Aa} ±0.14
	9	4.47^{Ce} ±0.02	7.54^{Bbc} ±0.10	8.80^{Ab} ±0.17	8.69^{Ab} ±0.09
Body & Texture (1-5 points)	0	3.54^{Cf} ±0.04	4.45^{ABe} ±0.02	4.56^{Ae} ±0.06	4.49^{ABe} ±0.04
	3	3.39^{Cf} ±0.03	4.31^{ABe} ±0.03	4.45^{Ae} ±0.04	4.38^{ABe} ±0.07
	6	3.26^{Cf} ±0.01	4.19^{ABe} ±0.03	4.31^{Ae} ±0.02	4.24^{ABe} ±0.06
	9	2.94^{Cfg} ±0.07	3.88^{B} ±0.02	4.07^{Aef} ±0.06	3.93^{ABf} ±0.03
Appearance &colour (1-5 points)	0	3.19^{C} ±0.03	4.73^{B} ±0.05	4.89^{Ae} ±0.03	4.82^{ABe} ±0.05
	3	3.05^{C} ±0.02	5.58^{Ade} ±0.04	4.77^{ABe} ±0.07	4.68^{ABe} ±0.06
	6	2.93^{Cfg} ±0.06	4.44^{Be} ±0.08	4.58^{Ae} ±0.05	4.53^{ABe} ±0.08
	9	2.57^{Cg} ±0.04	4.18^{ABe} ±0.02	4.29^{Ae} ±0.08	4.24^{ABe} ±0.03

[*]: Bacterial starter culture containing of *Lactobacillus delbrueckii ssp. bulgaricus* and *Streptococcus thermophilus* (as commercial yoghurt starter)

[**]: Bacterial starter culture containing of *Lactobacillus acidophilus* and bifidobacteria (with potential probiotic properties)

A, B,C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant (P≤0.05) differences between Storage period and Type of cereals

a,b,c,… : Means with the different small (a, b,…) superscript letters within the same column and property are significantly (P≤0.05) different Type of starter / parameters and Type of cereals

Therefore, from the economical point of view there is a possibility for the development the use of cereals pastes of barely, oat, rice and wheat for processing functional fermented camels' milk using either yoghurt or probiotic starters with improved nutritional , functional values and also with good organoleptic properties during storage at 5°C for 9 days. Further studies are needed to determine the effect of cereal-based camel's milk fermented products on the microflora of gastrointestinal tract of human.

REFERENCES

[1] Billings T. 1998; Available: http://www.livingfoods.com.

[2] Chavan JK and Kadman SS. Crit. Rev. Food Sci. Nutr. 1989; 28:349.

[3] Nout MJR, Darkar PK, Beuchat LR. Indigenous fermented foods. In: Doyle MP, Beuchat LR, editors. Food Microbiology: Fundamentals and Frontiers, 3rd edition. Washington DC: ASM 2007 Press. pp.817–835.

[4] Blandino A, Al-Aseeri ME, Pandiella SS, Cantero D and Webb C. Food Research International 2003; 36, 527–543.

[5] Svanberg U and Lorri W. Food Control 1997; 8, 319–327.

[6] Mensah P. Food Control 1997; 8, 271–278.

[7] Nout MJR and Motarjemi Y. Food Control 1997; 8, 221–226.

[8] Steinkraus KH. Food Science and Food Safety 2002; 1, 23–30.

[9] Soni SK and Sandhu DK (1990). Indian fermented foods: microbiological and biochemical aspects. Indian Journal of Microbiology,30, 135–157.

[10] Hirahara T (1998). Functional food science in Japan. In T. Mattila-Sandholm, & K. Kauppila (Eds.), Functional food research in Europe (pp. 19–20). Finland: Julkaisija-Utgivare. (BOOK)

[11] Pagni J. (1998). Demonstrating bacteria for health. VTT Biotechnology and Food Research (Catalogue 5).

[12] Jensen R.G. and Kroger M. (2000). The importance of milk and milk products in the diet. in: Handbook of Dairy Foods and Nutrition (Eds. G.D. Miller, J.K. Jarvis, L.D. McBean), 2nd ed., Boca Raton, Florida, pp. 51–52.

[13] Jelen P, Gallmann P, Coolbear T. (2003). Current and future applications of fermentation technology in the dairy industry. IDF Seminar on Aroma and Texture of Fermented Milk, p. 10.

[14] Valli C and Traill W B. Food Qual. Pref. 2005; 16, 291–304.

[15] Lourens-Hattingh A and Viljoen BC. Int. Dairy J, 2001; 11, 1–17.

[16] Abdulrahman A, Al-Saleh A, Metwalli M and Ismail A E. Int. J. Dairy Techn., 2011; 64:557-562.

[17] Magjeed NA. J. Saudi Chem. Society, 2005; 9:253.

[18] Agrawal R P, Budania S, Sharma P, Gupta R and Kochar D K. India. Diabetes Research and Clinical Practice, 2007; 76:290–296.

[19] Quan S, Tsuda H and Miyamoto T. Journal of the Science of Food and Agriculture, 2008; 88: 2688-2692.

[20] El-Agamy E I, Nawar M, Shamsia SM, Awad S and Haenlein GFW. Small Ruminant Research, 2009; 82: 1–6.

[21] Farah Z. J. Dairy Res. 1993; 60:603-626.

[22] Walstra P, Geurts T J, Noomen A, Lellema A and Van Boekel M A J (1999). Dairy Technology: Principles of Milk Properties and Processes (pp. 533–535). Marcel Dekker, New York, NY, USA.

[23] Hashim B, Khalil AH and Habib H. J. Dairy Sci., 2009; 92:857.

[24] Konuspayeva G, Faye B and Loiseau G. J. Food Composition & Analysis, 2009; 22: 95.

[25] Al-Alawi, A.; Ahmed, and Laleye C. Louis , (2011). Characterization of camel milk protein isolates as nutraceutical and functional ingredients. Collaborative Research Project SQU/UAEU CL/SQU-UAEU/01/08, SQU/UAEU 01-06-60/08. Sultan Qaboos University & United Arab Emirates University.

[26] Moslehishad M, Ehsani M R M, Salami S, Mirdamadi H, Ezzatpanah A N, Naslaji A A and Moosavi-Movahedi A. Int. Dairy J., 2013; 29: 82-87.

[27] Ashmaig A, Hasan A, El-Gaali E. Afr. J. Microbiol. Res., 2009; 3: 451-457.

[28] Gobbetti M, di Cagno R and de Angelis M. Food Science and Nutrition, 2010; 50(8), 716-727. PMid:20830633. http:// dx.doi.org/10.1080/10408398.2010.499770.

[29] Huggett AC and Schliter B. Nutr.Rev.,1996; 54:S143

[30] Charalampopoulos D, Wang R, Pandiella SS and Webb C. Int. J. Food. Microbiol., 2002 b; 92:851.

[31] Nomoto K. Journal of Bioscience and Bioengineering, 2005; 100: 583–592.

[32] Sharma G. and Ghosh B C. Indian Food Industry, 2006; 25, 68–73.

[33] Ziemer CJ and Gibson GR. Int. Dairy J.1998; 8:473.

[34] Charalampopoulos D, zquez V, Pandiella JA and Modelling SS. Biochem. Eng. J. 2009; 44 96–105.

[35] Kedia G, Wang R, Patel H and Pandiella SS. Proc.Biochem. 2007; 42:65–70.

[36] Wrigley C. (2004) "Cereals/overview," in Encyclopedia of Grain Science, C. Wrigley, Ed., pp. 187–201, Elsevier Academic Press, Oxford, UK,.

[37] Fletcher , R. J. (2004). "Pseudo-cereals/overview," in Encyclopedia Grain Science, C.Wrigley, Ed., pp. 488–493, Elsevier AcademicPress, Oxford, UK, 2004.

[38] Corsetti A and Settanni L. Food Research International, 2007, vol. 40, no. 5, pp. 539–558,

[39] Bouis HE. Nutrition 2000, 16:701–704

[40] Jones JM. Cereal Foods World 2006; 51:108–113.

[41] Jones PJH, Raeini-Sarjaz M, Ntanios FY, Vanstone CA, Feng JY, Prado FC, Parada JL, Pandey A and Soccol CR. Food Research International 2008; 41, 111–123.

[42] Oyewole OB. Food Control, 1997; 8:289.

[43] Sanni AI, Onilude AA and Ibidabpo OT. Food Chem., 1999; 65:35.

[44] Damiani P,Gobbetti M, Cossignani L, Corsetti A,Simonetti MS and Rossi J. LWT, 1996; 29:63.

[45] Nielsen, Suzanne S.(ed.) (1998). In: food Analysis. (2 nd Ed). Aspen Publishers, Inc., Maryland.

[46] AOAC. (2012). Official Methods of Analysis. Association of Official Analytical Chemists, 19th ed. ; Gaithersburg, MD, USA.

[47] Farouq K and Haque ZU. J. Dairy Sci. 1992; 75: 2676-2680.

[48] Lees GJ and Jago GB. Aust.J..Dairy Technol., 1969; 24:181

[49] Lees GJ and Jago GB. J. Dairy Res., 1970; 37:129

[50] Djurdjevic J D, Macej O and Jovanovic S. J. Agric. Sci., 2001; 46: 123- 135.

[51] Wehr H.M. and Frank J F (eds)(2004). In: standard Methods for the Examination of Dairy Products. (17th Ed.), American Public Health Association, Washington, DC.

[52] Dave R I and Shah NP. J. Dairy Sci., 1996; 79:1529

[53] Clark S; Costello M, Drake M and Bodyfelt F (eds.) (2009). The sensory Evaluation of Dairy Products. (2 nd Ed), pp.191-223. Springer Science Business Media, LLC, New York, USA.

[54] SPSS (2007). Statistical Package for Social Science. SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL, USA.

[55] Akalin AS. Egypt. J.Dairy Sci., 1996; 24:227

[56] Salama FMM. Egypt. J.Dairy Sci., 2002; 30:177

[57] Hassan AN. J. Dairy Sci., 2008; 91:1282.

[58] Purohit DH, Hassan AN, Bhatia E, Zhang X and Dwivedi C. J. Dairy Sci., 2009; 92:847.

[59] De Vuyst L and Degeest B. FEMS Microbiol. Rev., 1999; 23:153

[60] Gonzalez S, Morata de Ambrosini V, Manca de Nadra M, Pesce de Ruiz Holgado A. and OliverG. J. Food Prot., 1994; 57:436.

[61] Ostlie HM Helland MH and Narvhus JA. Int. J. Food Microbiol., 2003; 87:17.

[62] Salmeron I, Fucions P, Charalampopoulos D and Pandiella SS. Food Chem., 2009; 117:265.

[63] Tamime AY and Robinson R K (eds.)(1985). Yoghurt: Science and Technology. (1st Ed.), pp.295-327 Pergamon Press Inc., New York, USA.

[64] Barrantes E, Tammime AY, Muir DD and Swoed AM. J. Society Dairy Technol., 1994; 47:61.

[65] Salama FMM and Hassan FAM. Egypt. J. Dairy Sci., 1994; 22:31

[66] Akin MB, Akin MS and Kirmaci Z. Food Chem., 2007; 104:93.

[67] Vinderola CG, Bailo N and Reinheimer JA. Food Res. Int., 2000; 33:97.

[68] Sanders ME and Huis in't Veld JHJ.Antoine van Leeuwenhoek, 1999; 76:293.

[69] Abu-Taraboush HM, Al-Dagal MM and Al-Royli MA. J. Dairy Sci., 1998; 81:354.

[70] Abdel Rahman IE, Dirar, HA and Osman MA. African J. Food Sci., 2009; 3:398.

[71] Marklinder I. and Lönner C. Food Microbiol., 1992; 9:197.

[72] Jaskari J, Salovaara H, Mattilla-Sandholm T and Putanen K. (1993). The effect of oat β-glucan on the growth of selected *Lactobacillus* spp. and *Bifidobacterium* spp. In: Aalto-Kaarlehto, T. and Salovaara, H.(eds.), pp.242-244. Proceedings of the 25th Nordic Cereal Congress, Univ.Helsinki, Helsinki

[73] Charalampopoulos D, Pandiella, SS and Webb C. J. Appl. Microbiol., 2002 a; 92:851.

[74] Fguiri I, Ziadi M, Abassi M, Arroum S and Khorchan T. African Journal of Microbiology Research, 2012; 6: 7185-7192.

[75] Lazaridou A and Biliaderis GG. J.Cereal Sci., 2007; 46:101.

[76] Beal C, Skokanova J, Latrille E, Martin N. and Corrieu G. J. Dairy Sci., 1999; 82:673–681

[77] Barnes HA, Hutton JF and Walters K. (1993). An Introduction to rheology, p. 199, Elsevier, Amsterdam, the Netherlands.

[78] DE Lorenzi L, Pricl S. and Torriano G. Int. Dairy J. 1995; 5, 661–671.

[79] N sabimana C, Jiang B and Kossah R. Int. J. Dairy Technol. 2005; 58:129–137.

[80] Abu-Jdayil B, Shaker RR and Jumah RY. International Journal of Food Properties 2000; 3: 207–216.

[81] Folkenberg DM, Dejmek P, Skriver A, Guldager HS and Ipsen R. Int. Dairy J., 2006:16:111.

[82] Moreira M, Abraham A and Antoni GDe . J. Dairy Sci., 2000; 83:395

[83] Vijayalakshmi R, Nareshkumar C and Dhanalakshmi B. Egypt.J. Dairy Sci., 2010; 38:53.