The effects of various stabilizers on physiochemical properties of camel's milk yoghurt

Alaa H. Ibrahim[1*] and Salah A. Khalifa[2]

[1.] Animal and Poultry Breeding Dept., Desert Res. Cent., Cairo, Egypt
[2.] Food Sci. Dept., Fac. Agric., Zagazig Univ., Egypt
alaa.drc@gmail.com

Abstract: The effect of stabilizers addition on physicochemical and organoleptic properties of yoghurt made from camel milk was studied. Three stabilizers were used, A (gelatin E441, mono & diglyceride of fatty acids E471), B (guar gum E412, sodium carboxymethyl cellulose E466 and mono & diglyceride of fatty acids E471) and C (modified starch E1422 and mono and diglyceride of fatty acids E471). The addition rate of stabilizers to camel milk was 0.5%, 1.0% and 1.5%, w/w. The products were stored at 5±2°C for 21 days. Addition of stabilizers significantly decreased the syneresis, and increased viscosity and water holding capacity of camel milk yoghurt ($p \leq 0.05$), also enhanced their sensory acceptability. Significant effects of stabilizers type and addition rate on acidity, moisture content and total solids of camel milk yoghurt were observed. The water holding capacity and susceptibility to syneresis of camel milk yoghurt were significantly affected by type and quantity of stabilizer used. The optimum results were recorded using stabilizers A, B and C in order. Increasing the amount of the stabilizer added, resulted in water holding capacity and lower susceptibility to syneresis values. Acidity and pH values of camel milk yoghurt were significantly affected by type of stabilizer. Addition of stabilizers caused the highest acidity and the lowest pH of camel milk yoghurt compared to control. The stabilizers treated camel milk yoghurt had higher total solid, protein and fat than the control. Camel milk yoghurt containing stabilizer had higher viscosity than the control samples. The images of scanning electron microscope showed that the stabilizers occupied the void space within casein particle network. Treated camel milk yoghurts had more systematically and smoothly distributed proteins with a bit coarse structure as well as less porosity in protein network. As well as the addition of stabilizers to camel milk yoghurt to the merger of casein micelles with each other, which increases the cohesion flat casein compared with a control sample. The treatment B which retained the highest rate of water holding capacity had colloidal or ropiness texture, while cohesion textures increased in both treatments A and B. Adding stabilizer A (gelatin E441, mono & digilycerid of fatty acids E471) at a level up to 1.5%, to camel milk yoghurt is recommended to stabilize the texture without affecting the overall acceptability of the product.

[Alaa H. Ibrahim and Salah A. Khalifa. **The effects of various stabilizers on physiochemical properties of camel milk yoghurt.** *J Am Sci* 2015;11(1):15-24]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 3

Keywords: Physico-chemical, organoleptic properties, camel milk yoghurt, microstructure and stabilizers.

1. Introduction

Stabilizers are sometimes referred to as hydrocolloids and their mode of action in yoghurt includes the binding of water and promotion of an increase in viscosity. Texture is one of the most important characteristics that define the quality of yoghurt and affects its appearance, mouth-feel and overall acceptability. The most frequent defects related to yoghurt texture, which may lead to consumer rejection, are apparent viscosity variations and the occurrence of syneresis **(Kroger 1975).** These changes may be due to variations in milk composition, as well as changes in processing, incubation and storage conditions. Thickeners and dairy ingredients have been widely added to the milk base in order to prevent these defects, to provide an acceptably firm texture and to reduce syneresis. Two of the most frequently used thickeners are hydrocolloids **(Phillips and Williams, 2009)**. Starch used in yoghurt to increase its viscosity, improve its mouth-feel, and prevent syneresis. Starch granules imbibe water and swell to many times their original size, resulting in increased viscosity of the solution. It is one of the most frequently used thickening agents in yoghurt production due to its processing ease and low cost when compared with other hydrocolloids **(Foss 2000 and Phillips & Williams, 2009**).

A hydrocolloid ingredient may act as an emulsifying agent, as a stabilizing agent, or in both of these roles. An emulsifying agent (emulsifier) is a surface-active ingredient which adsorbs at the newly formed oil-water interface during emulsion preparation, and it protects the newly formed droplets against immediate recoalescence. Polysaccharides are predominantly hydrophilic in molecular character, and most hydrocolloids are not surface-active. They cannot act as primary emulsifying agents. There is really only one hydrocolloid- namely, gum arabic - which is commonly employed as an emulsifying agent. The main emulsifying agents used in food processing are the proteins, especially those derived from milk or eggs. A stabilizing agent (stabilizer) is an ingredient that confers long-term stability on an emulsion, possibly by a mechanism involving adsorption, but not necessarily so. In oil-in-water (O/W) emulsions, the stabilizing action of hydrocolloids such as xanthan, carboxymethycellose, carrageenan, etc., are traditionally attributed to the structuring, thickening and gelation of the aqueous continuous phase. The expression `emulsifying agent' is to be preferred over the more concise `emulsifier'. This is because the latter term normally implies membership of the class of small-molecule surfactants, comprising lipid-based ingredients such as monoglycerides (e.g., GMS), phosphorlipids (lecithin) and polysorbates (Tweens). The functional role of these small molecule emulsifiers in food technology is typically not for emulsion making, but for other reasons: controlling fat morphology and crystallization; promoting shelf-life through interaction with starch; and destabilizing emulsions by competitive protein displacement from the oil/water interface **(Dickinson, 1992 and Phillips, & Williams2009)**.

Edwards and Garcia (2009) explained the health effects of food hydrocolloids which dependent on how they are incorporated into foods and in the diet. There are many hydrocolloid carbohydrates naturally present in plant foods as part of the cell wall, such as hemicelluloses and pectin, or with other more specific roles within the plant such as storage polysaccharides like guar gum, exudates like gum acacia, and husk polysaccharides such as ispaghula. There are also alginates and bacterially produced hydrocolloids such as gellan and xanthan. Hydrocolloids can also be incorporated in small amounts into food products as stabilizers, emulsifiers and fat substitutes. Guar gum levels of <1% is typically added to food products. However, health beneficial effects of guar gum are achieved with higher levels (3±5%). Increasing the amount of dietary fibre within food formulation may result in compromising the product's organoleptic properties. However, hydrocolloids such as partially hydrolysed guar gum have a higher potential to be successfully incorporated into different foods due to their lower viscosity **(Ellis *et al.* 1985)**

The aim of the present work was to study the effect of the addition of various stabilizers and emulsion stability, on physico-chemical and organoleptic properties of camel milk yoghurt.

2. Materials and methods

Camel milk:

Fresh whole camel milk (fat 3.12%, protein 3.22%, total solids 13.11% and pH 6.6) from healthy and uninfected Magrabi camels (*Camelus dromedarius*) was obtained from Sidi-Barani areas, Matrouh Governorate, North West Coast of the Alexandria city, Egypt.

Stabilizers:

Gelatin E441, mono and diglyceride of fatty acid E471, sodium carboxymethyl cellulose E466, guar gum E412 and modified starch E1422 (Acetylated distarch adipate), was obtained from EGY DAIRY (10^{th} of Ramadan City, Egypt).

Starter cultures:

Freeze dried DVS-ABY-1 Nu-TRISH yoghurt cultures containing *Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, *L. acidophilus* LA-5 and *Bifidobacterium* BB-12 were obtained from Chr. Hansen Inc. Laboratories, Denmark, by Misr Food Additives (MIFAD), Egypt.

Experimental and yoghurt manufacture

Stabilizers A, B and C (gelatin E441 and mono and diglyceride of fatty acid E471 (1:1); guar gum E412, sodium carboxymethyl cellulose E466 and mono and diglyceride of fatty acid E471 (1:1:1) and modified starch E1422 and mono and diglyceride of fatty acid E471 (1:1), respectively) were added at ratio 0.5%, 1.0% and 1.5%, (w/w) to fresh camel milk. Also, camel milk without stabilizers was serving as control. The milk was then homogenised at 400Kpa. The untreated and stabilizers treated camel milk samples were heated at 90°C for 10min., cooled to 42°C and inoculated with freeze dried ABY-1 culture (2%), distributed in 100 ml sterile plastic containers followed by incubation at 42°C until a pH of 4.5–4.6 was reached. The plastic containers were covered and stored at 5±2°C for 21 days.

Physico-chemical measurements:

According to **AOAC (2005)** yoghurt samples were chemically analyzed. Protein was determined using micro Kjeldahl method (TN × 6.38), fat and titratable acidity as lactic acid %. pH were determined as described by **Ling (1963)**. Total solids were measured according to **IDF (1982)**. Viscosity of the samples was determined at 15 °C using a digital Viscometer, (Brookfield LDV-I+ viscometer, Brookfield Engineering Labs. Inc. MA. USA) and spindle number LV 2. The spindle was rotated at 12 rpm. The readings were recorded at the 15^{th} second of the measurement period as centipoises (cP) as described by **Ranadheera *et al.* (2012)**. The yoghurt susceptibility to syneresis (STS) was determined by the method reported by **Isanga and Zhang (2009)**. This involved placing a 100 ml yoghurt sample in a funnel lined with a Whatman filter paper number 1. After 6 h of drainage, the volume of whey collected in a measuring cylinder. The following formula was used to calculate STS: STS (%) = V1/V2 × 100 where: V1 = volume of whey collected after drainage; V2 = volume of yoghurt sample. The water holding capacity (WHC) of yoghurt was measured by centrifugation of a five gram yogurt sample at 4500 rpm for 30 min at 10°C (Jouan, MR1822, France). The WHC was calculated as follows: WHC (%) = (1-W1/W2) × 100 where: W1 =

weight of whey after centrifugation, W2 = yoghurt sample weight (**Isanga and Zhang, 2009**).

Scanning electron microscopy:

Samples of yoghurt were fixed in 2.5% glutaraldehyde in cacodylate buffer (pH 7.2) for at least 1 h. After rinsing three times in cacodylate buffer, samples were postfixed in a 1% buffered osmium tetroxide for one hour. The fixed samples were dehydrated using a graded alcohol series (20%, 40%, 60%, 70% and 90%) finishing with three changes of 100% alcohol then critical point dried from liquid CO_2. At least three dried samples of each yoghurt were fractured, mounted on aluminium stubs, and coated with gold in a K550X sputter coater (England) as described by (**Puvanenthiran *et al.*, 2002)**. At least four images of typical structures at 1000×magnification were recorded using a Scanning Electron Microscope (FEI company, Netherlands) Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 30 K.V., magnification14x up to 1000000 and resolution for Gun.1n) by the Egyptian Mineral Resource Authority, Central Laboratories Sector, Dokki, Giza, Egypt.

Sensory evaluation

Sensory evaluation of yoghurt samples was conducted by panellists. The panellists were asked to evaluate the colour and appearance, aroma, body & texture, taste and overall acceptability when fresh and after 21 days of storage, based on a 9 point **(Ranadheera *et al.*, 2012)**.

Statistical analysis

In 3 (ingredient type; A, B and C) × 3 (addition rate; 0.5% w/w, 1% w/w and 1.5% w/w) factorial arrangement, analysis of variance (ANOVA) was applied, and Duncan's multiple range test was used to determine the differences using SPSS© 16.0 for Windows (SPSS Inc., Chicago, IL, USA). P value is ≤ 0.05, it was considered statistically significant. All experiments were conducted in triplicate.

3. Results and discussion

Physico-chemical characteristics:

In the present study, the pH of camel milk yoghurt demonstrated wide variations during storage. The initial titratable acidity and pH of the fresh camel milk yoghurt samples with stabilizers were 0.73% and 0.82 % and 4.41 and 4.65 respectively, as compared with control samples 0.74% and 4.64. The titratable acidity of camel milk yoghurt with stabilizers and control samples were increased to 0.86 and 0.84 % after 21 days, respectively (Table1). The pH of samples with or without stabilizers was reduced to 4.27 and 4.31 after 21 days. Higher acidity of the yogurt with stabilizers was obtained compared with control yoghurt samples. However, at the end of the storage period, it was noticed the decrease of the acidity % with increase of the added per cent of stabilizer in all camel milk yoghurt samples containing stabilizers. The pH of the yoghurt base was noted of yogurts samples A0.5, A1.5 and C 0.5%, respectively. Further, overall higher acidity and declines in the pH of all types of stored yogurts were recorded (Table 1). Similar results have been reported by several other researchers for goat's milk yogurts **(Guler-Akin and Akin, 2007)** and cow's milk yogurts (**Dave and Shah, 1997a, 1997b; Vinderola *et al.*, 2000; Ekinci and Gurel, 2008)**. There were significant differences in pH between control yoghurt and all of the camel milk yoghurts at the end of the storage. The pH value decline may be due to continued fermentation by the lactic acid bacteria and the contribution of the acidity of the added stabilizers. Yoghurts in this study were produced using a culture containing both *S. thermophilus* and *L. delbrueckii* spp *bulgaricus* which accelerate post fermentation acidification in yoghurt during storage compared to starter cultures which are devoid of *L. delbrueckii* spp *bulgaricus* **(Kailasapathy *et al.*, 2008)**.

Total solids, protein and fat contents were found to be higher in yoghurts with stabilizers, compared with control yoghurts reflecting higher total solids content in treated yogurts due to addition of stabilizers **(Mehanna, *et al.*, 2013)** (Table 1). Changes in these parameters, especially total solids and fat content may affect certain other physico-hemical properties such as syneresis, water holding capacity and viscosity. Syneresis, an undesirable property in yogurt products, is the effect of liquid separating from the yoghurt curd **(Wu, *et al.*, 2001)**. Syneresis was found to be significantly lower in stabilizers yoghurt samples than in the control this probably due to its higher total solids. High fat content in yoghurt has been associated with lower syneresis values **(Keogh & O'Kennedy, 1998 and Isanga & Zhang, 2009**).

Serum separation occurs in fermented milk products due to the aggregation and sedimentation of casein particles during storage. The use of the stabilizers was found to be necessary to prevent serum separation in fermented milk **(Lucey *et al.*, 1999; Towler, 1984)**. When the stabilizers were added to yoghurt, serum separation was reduced compared to that in yoghurt without any stabilizer (Table 2). The reduction of serum separation to zero was possible when high concentrations (1.5%) were used. **Guinee *et al.* (1995)** and **Keogh and O'Kennedy (1998)** reported that gelatin at 0.5% level reduced the syneresis in stirred yogurt. However, use of modified starch at a level of 1.5 % reduced syneresis but did not prevent serum separation in yogurts in this study. **Ares *et al.* (2007)** reported that the stirred yogurt manufactured with the addition of 1 mg/g of starch showed the same syneresis values as the control sample. However, the addition of 5 or 10 mg/g of starch reduced syneresis by

18%. **Okoth *et al.* (2011)** reported that the skimmed milk powder with modified corn starch implemented to produce this high quality and profitable yoghurt. Polysaccharide gums increase viscosity in dispersions by nonspecific entanglement preventing the interactions of dispersed particles **(Fox *et al.*, 1993)**. In this study, increased viscosity by the use of hydrocolloids was associated with the reduction in serum separation in camel milk yoghurt. When the samples containing concentration of stabilizers (0.5-1.5%) were compared, the increase in viscosity is much greater with A and B and this reflects to the serum separation levels **(Koksoy and Kilic, 2004)**. Therefore, the interactions between casein particles and modified starch also contribute to the reduction in serum separation in addition to the effect of increased viscosity. Low level of A and B might not cover all the casein particles and create sufficient electrostatic and steric repulsions to stabilize the dispersion **(Dickinson, 1998; Syrbe *et al.*, 1998)**. Gelatin has been used in yoghurt to prevent syneresis due to its high water holding capacity. A high concentration of gelatin was necessary to minimize the serum separation. Gelatin at a level of 1.5% gelatin was found to form of a continuous interconnected network that entrap water in yoghurt **(Fiszman and Salvador, 1999)**. The effects of nonadsorbing polysaccharides, guar gum, on serum separation were attributed to the increased viscosity as they do not interact with casein particles. This change in the gel network was explained by depletion flocculation mechanism where repulsive forces between the polysaccharide and protein lead to their separation and exclusion of the aqueous phase from their surroundings. When the concentration of A, B and C were increased to 1.5%, this effect might be enhanced completely immobilizing the particles and preventing serum separation. The effect of guar gum up to 1.0% in the reduction of serum separation can be explained similar to gelatin at 1.5% and modified starch at 1.5% as they have similar structures.

Wu *et al.* (2001) demonstrated that the water holding capacity was related to the ability of the proteins to retain water within the yoghurt structure. These researchers further suggested that fat globules in the milk may also play an important role in retaining water. In this study, yoghurts with added stabilizers demonstrated significantly higher water holding capacity compared to control yoghurts, possibly reflecting the higher protein and fat content of the treated yoghurt compared to control yoghurt (Table 2). The viscosity of yoghurt with stabilizes was also found to be higher than that of control yoghurts, in line with the higher level of total solids in treatments yoghurts as described by, **Tamime and Robinson (1999), Martin-Diana *et al.* (2003)** and **Isanga and Zhang (2009)**. **Isanga and Zhang (2009)** reported that high levels of fat may also contribute to a higher viscosity of yoghurts where homogenised milk was used in production, since homogenisation facilitates copolymer formation between casein and the fat globules thereby strengthening the gel network.

The water holding capacity of yoghurts with stabilizers (63.24-97.75 g/100 g) was significantly ($P \leq 0.05$) higher than that of the fresh control samples (45.11 g/100 g). The difference in WHC of the yoghurts may be attributed to the properties of the different proteins present in them. Interactions of water with proteins are very important in food systems because of their effects on the flavour and texture of foods. Intrinsic factors affecting water holding capacity of food proteins include amino acid composition, protein conformation and surface polarity/ hydrophobicity **(Barbut, 1999)**. Stabilizers have two basic functions in yoghurt i.e. the binding of water and improvement in texture **(Thaiudom & Goff, 2003)**. Stabilizers bind with water to reduce water flow in the matrix space and some may interact with protein in the food matrix, further increase hydration behavior **(Tamime & Robinson, 1999; Duboc & Mollet, 2001)**. On the other hand, the susceptibility to syneresis (STS) of yoghurts with added stabilizers (0 - 11.88 ml/100 ml) was significantly ($P \leq 0.05$) lower than that of control samples (37.21 ml/100 ml). Lower STS of A, B and C than control may be explained by the higher fat content of A, B and C compared to control (Table 2). It was earlier reported **(Staff, 1998)** that low-fat yoghurts tend to have higher degree of syneresis than high-fat yoghurts. Since yoghurt is usually prepared from homogenized milk to improve stability, this process coats the increased surface of fat globules with casein, enabling the fat globules to participate as a copolymer with casein to strengthen the gel network and reduce syneresis **(Keogh & O'Kennedy, 1998)**.

The viscosity of camel milk yoghurt was increased with increasing concentrations of added stabilizers (Table 2). The highest viscosity in camel milk yogurt was obtained by treatments B followed by A and C. The increase of viscosity in camel milk yoghurt containing different ratios of stabilizers may be due to the interaction between the stabilizer and casein particles thus contributing a strong gel when the concentration was doubled **(Koksoy and Kilic, 2004)**. **Güven (1998)** found that gelatin at a concentration of 0.5% increased the viscosity in yoghurt. **Schmidt and Smith (1992)** also found that the flow behavior index of aqueous solution of nonfat dry milk (11%) containing guar gum was reduced when the concentration of guar gum was increased from 0.05 to 0.2%. As the guar gum is not affected by pH, similar behavior is expected in study. **Bourriot *et al.* (1999)** also reported that guar gum at a concentration of 0.2% mixed with micellar casein exhibited thixotropic behavior.

Table 1: Physico-chemical characteristics of camel milk yoghurt with stabilizers (0.5%, 1.0% and 1.5%) when fresh and after 21 days of storage.

Characteristic		Treatments										Main effects
		Control	A			B			C			
			0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	
Titratable acidity (%)	Fresh	0.74±0.11	0.82±0.01	0.8±0.07	0.76±0.08	0.8±0.04	0.76±0.07	0.75±0.03	0.79±0.04	0.75±0.02	0.73±0.05	0.77±0.05^{b}
	21days	0.86±.04	0.84±0.04	0.83±0.04	0.81±0.1	0.83±0.04	0.80±0.04	0.78±0.06	0.81±0.01	0.78±0.01	0.75±0.06	0.81±0.05^{a}
	Main effects	0.80±0.09^{ab}	0.83±0.03^{a}	0.82±0.05^{a}	0.79±0.09^{ab}	0.82±0.04^{a}	0.78±0.06^{ab}	0.77±0.05^{ab}	0.79±0.04^{ab}	0.77±0.02^{ab}	0.74±0.05^{b}	0.79±0.06
pH	Fresh	4.64±0.09	4.41±0. 1	4.48±0.2	4.55±0.11	4.43±0.08	4.53±0.12	4.6±0.11	4.51±0.15	4.57±0.24	4.65±0.12	4.54±0.14^{a}
	21days	4.27±0.17	4.31±0.03	4.33±0.09	4.41±0.1	4.32±0.16	4.37±0.04	4.43±0.13	4.38±0.23	4.45±0.1	4.54±0.06	4.38±0.06^{b}
	Main effects	4.46±0.24^{ab}	4.36±0.09^{b}	4.41±0.16^{b}	4.48±0.12^{ab}	4.38±0.13^{b}	4.45±0.12^{ab}	4.52±0.14^{ab}	4.45±0.19^{ab}	4.51±0.18^{ab}	4.60±0.10^{a}	4.46±0.16
Total solids (%)	Fresh	13.12±0.33	13.62±0.04	14.15±0.73	14.76±0.36	13.77±0.10	14.26±0.29	14.78±0.54	13.65±0.01	14.32±0.70	14.65±0.33	14.11±0.69^{b}
	21days	14.34±0.69	14.56±0.31	15.03±0.95	15.68±0.66	14.63±0.54	15.1±0.84	15.69±0.51	14.71±0.53	15.12±0.24	15.54±0.22	15.02±0.68^{a}
	Main effects	13.73±0.82^{c}	14.09±0.55^{bc}	14.59±0.90^{ab}	15.22±0.69^{a}	14.23±0.61^{bc}	14.68±0.73^{ab}	15.24±0.68^{a}	14.18±0.67^{bc}	14.72±0.64^{ab}	15.10±0.55^{a}	14.58±.081
Protein (%)	Fresh	3.27±0.17	3.55±0.11	3.61±0.07	3.63±0.25	3.48±0.41	3.5±0.42	3.52±0.49	3.44±0.31	3.41±0.25	3.42±0.12	3.48±0.26^{b}
	21days	3.32±0.22	3.64±0.41	3.77±0.35	3.86±0.13	3.52±0.02	3.71±0.4	3.68±0.30	3.85±0.58	3.55±0.33	3.51±0.14	3.64±0.30^{a}
	Main effects	3.30±0.18^{b}	3.60±0.27^{ab}	3.69±0.24^{ab}	3.75±0.22^{a}	3.50±0.26^{ab}	3.61±0.28^{ab}	3.60±0.37^{ab}	3.65±0.47^{ab}	3.48±0.27^{ab}	3.47±0.13^{ab}	3.65±0.29
Fat (%)	Fresh	3.15±0.35	3.16±0.24	3.15±0.45	3.14±0.56	3.16±0.34	3.15±0.25	3.16±	3.17±0.43	3.16±0.24	3.18±0.52	3.16±0.31^{a}
	21days	3.20±0.50	3.18±0.22	3.17±0.43	3.16±0.31	3.16±0.64	3.18±0.52	3.19±0.21	3.19±0.31	3.18±0.52	3.19±0.21	3.18±0.34^{a}
	Main effects	3.18±0.39^{a}	3.17±0.21^{a}	3.16±0.39^{a}	15.15±0.39^{a}	3.16±0.46^{a}	3.17±0.37^{a}	3.18±0.16^{a}	3.18±0.34^{a}	3.19±0.35^{a}	3. 17±0.36^{a}	3.17±0.32

Mean (±SE). ^{a,b,c} Values in the same row having different superscripts differ significantly ($p < 0.05$).
A=gelatin E441 and mono & diglyceride of fatty acid E471 (1:1). **B**= guar gum E412, sodium carboxymethyl cellulose E466 and mono & diglyceride of fatty acid E471, (1:1:1). **C**= modified starch E1422 and mono & diglyceride of fatty acid E471 (1:1).

Table 2: Water holding capacity (WHC), susceptibility to syneresis (STS) and viscosity of camel milk yoghurt with stabilizers (0.5%, 1.0% and 1.5%) when fresh and after 21 days of storage.

Characteristic		Treatments										Main effects
		Control	A			B			C			
			0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	
WHC (%)	Fresh	45.11±5.12	63.24±12.58	78.47±13.24	91.34±2.73	73.87±12.62	95.41±8.11	97.75±3.75	59.21±3.11	67.14±10.82	85.62±14.41	75.72±18^{a}
	21days	40.33±7.9	61.21±5.79	75.65±14.42	88.17±2.08	69.35±9.1	93.22±4.57	94.19±0.55	57.54±8.66	64.36±7.04	82.35±1.12	72.64±17^{a}
	Main effects	42.72±6.50^{g}	62.23±8.83^{ef}	77.06±12.48^{cd}	89.76±2.78^{ab}	71.61±10.15^{de}	94.32±6.01^{ab}	95.97±3.09^{a}	58.38±5.89^{f}	65.75±8.30^{ef}	83.99±9.31b^{c}	74.18±18
STS (%)	Fresh	37.21±3.0	7.24±0.90	2.78±0.93	0.0	4.67±3.68	0.0	0.0	11.88±6.67	9.65±4.6	7.47±6.80	8.09±11 ^{b}
	21days	46.51±5.26	10.12±4.65	4.83±1.41	2.52±0.94	6.23±1.01	3.54±0.67	2.1±0.04	13.34±3.80	11.51±5.07	9.25±1.0	10.98±11^{a}
	Main effects	41.86±6.3^{7a}	8.68±3.39^{bc}	3.81±1.55^{d}	1.26±1.50^{d}	5.45±2.56^{cd}	1.77±1.98^{d}	1.05±1.15^{d}	12.61±4.92^{b}	10.58±4.45^{b}	8.36±4.44^{bc}	9.54±12.01
Viscosity (cP)	Fresh	325±40	397±10	1075±117	1325±121	439±128	1700±174	2250±96	414±55	925±80	1200±58	1005±623^{a}
	21days	331±81	411±14	1114±100	1382±61	456±31	1821±319	2314±210	435±151	1042±183	1321±134	1062±659^{a}
	Main effects	328±57.23^{e}	404±13.31^{e}	1094±99.65^{d}	1353±91.22^{c}	447.5±83.81^{e}	1760.5±2393^{b}	2282±150.18^{a}	424.5±102^{e}	983.5±141^{d}	1260.5±113^{c}	1033±636

Mean (±SE). ^{a,b,c} Values in the same row having different superscripts differ significantly ($p < 0.05$).
A=gelatin E441 and mono & diglyceride of fatty acid E471 (1:1). **B**= guar gum E412, sodium carboxymethyl cellulose E466 and mono & diglyceride of fatty acid E471, (1:1:1). **C**= modified starch E1422 and mono & diglyceride of fatty acid E471 (1:1).

Microstructure of camel milk yoghurt:

Microstructure of yoghurt samples are given in **Fig. 1, 2, 3 and 4**. In general, treated yoghurts (A, B and C) had more systematically and smoothly distributed casein with a bit coarse structure as well as less porosity in casein network. This might be attributed to hydrocolloids and emulsion stability catalyzed cross-link formation between milk proteins as reported by **Lorenzen *et al.* (2002)**. The appearance of casein micelles were less defined. These differences were probably due to the interactions between casein micelles and stabilizers through mainly hydrophobic interaction leading to the formation of caseine-stabilizers complexes **(Wang *et al.*, 2012)**. The gel in the control camel milk yoghurt had weakly appearances which aqueous phase (whey) spread between casein layers. Examination of the fixed gels under the SEM showed that the casein network in the control sample was a coarse structure of relatively large globular aggregates in a network forming large pores (Fig. 1). **Tamime and Robinson, (1999)** reported that, in typical scanning electron micrographs of yogurt with stabilizers, a casein matrix is visible with various forms and sizes of compact area**.** Scanning electron microscopy (SEM) photographs of fresh camel milk yoghurt with stabilizer A (gelatin E441 and mono & diglyceride of fatty acid E471 (1:1)). No significant differences between the concentrate of stabilizer added to the milk. The casein matrix appears as closely packed lumps direly granulated more (Fig.2: 1, 2 and 3). SEM of fresh camel milk yoghurt with stabilizer B (guar gum E412, sodium carboxymethyl cellulose E466, and mono & diglyceride of fatty acid E471, (1:1:1)), casein matrix appear of granular shape as in chemical analysis with more water holding capacity. A colloidal appearance due to the high WHC 73.87% in treatment B 0.5% (Fig.3: 1), while in samples with 1 and 1.5% of stabilizer B (WHC, 95.41 and 97.75%, respectively) the higher addition of stabilizer led to more compact gels (Fig.3: 2 and 3). Scanning electron microscopy of fresh camel milk yoghurt with stabilizer C (modified starch E1422 and mono & diglyceride of fatty acid E471 (1:1)) Fig.4: 1, 2 and 3, reflected the compact structure of casein network with less water holding capacity than treatment with stabilizer B. The addition of stabilizers to camel milk yoghurt to the merger of casein micelles with each other, which increases the cohesion flat casein compared with a control sample. The treatment B which retained the highest rate of water holding capacity B 1, 1.5% had colloidal or ropiness textures, while cohesion textures increased in both treatment A and B of camel milk yoghurt.

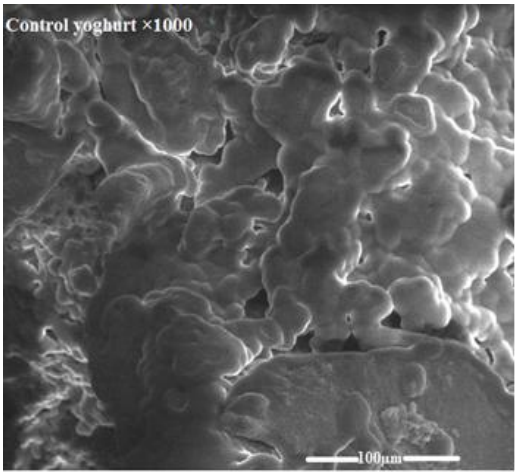

Fig. 1. Scanning electron microscopy (SEM) photographs (×1000) of fresh control camel milk yoghurt.

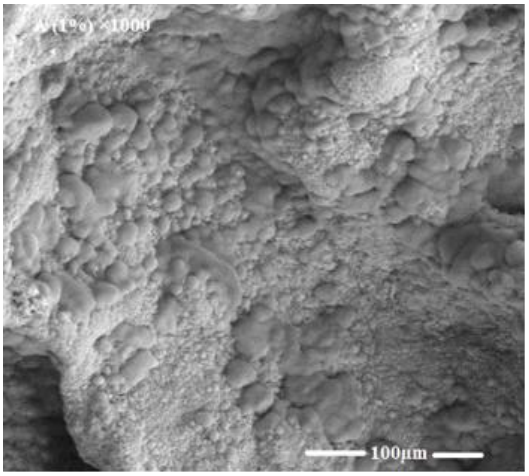

Fig. 2. 2. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer A (1%).

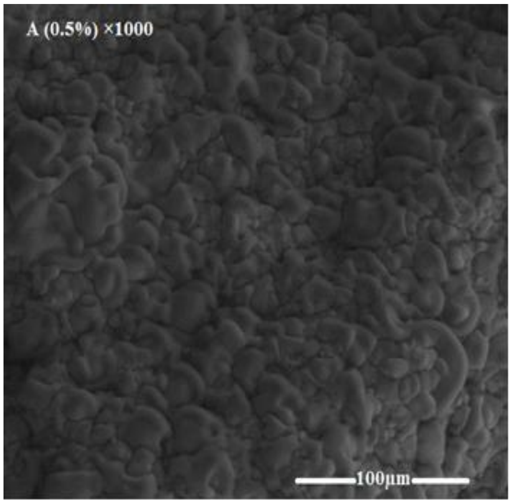

Fig. 2.1. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer A (0.5%).

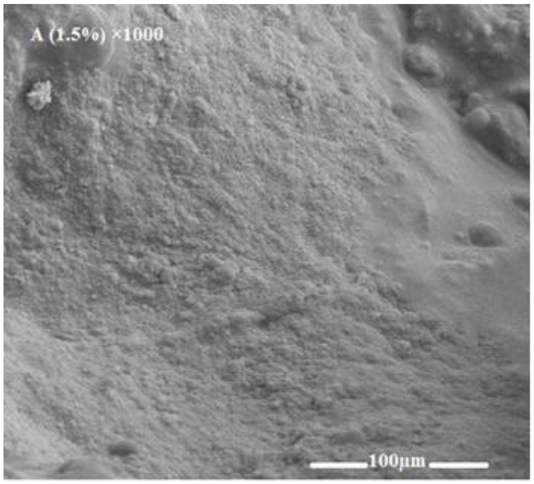

Fig. 2.3. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer A (1.5%).

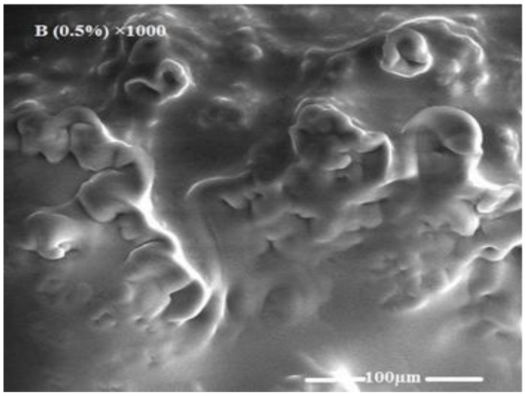

Fig. 3.1. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer B (0.5%).

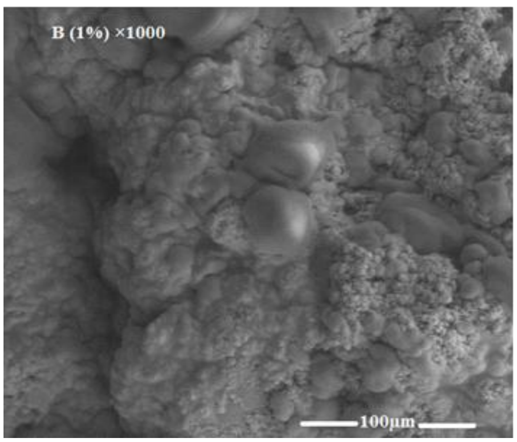

Fig. 3.2. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer B (1%).

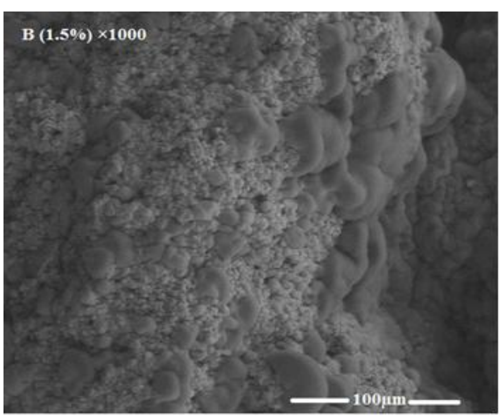

Fig. 3.3. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer B (1%).

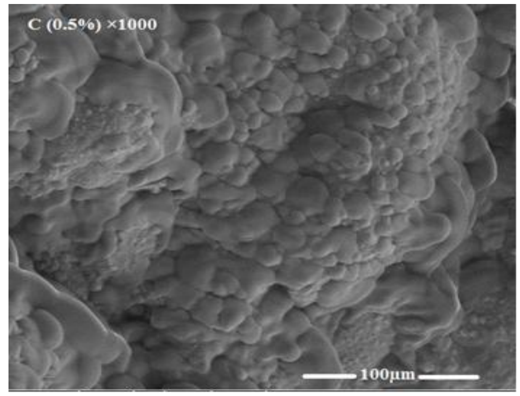

Fig. 4.1. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer C (0.5%).

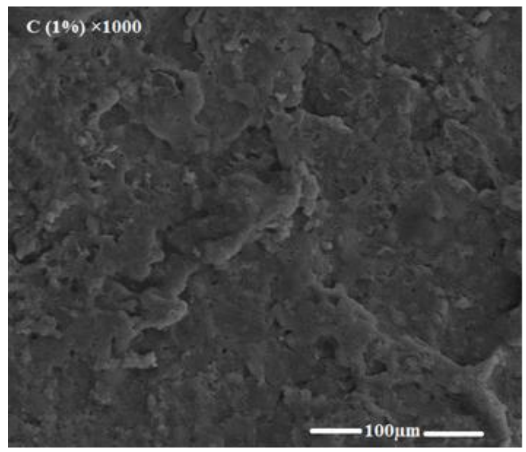

Fig. 4.2. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer C (1%).

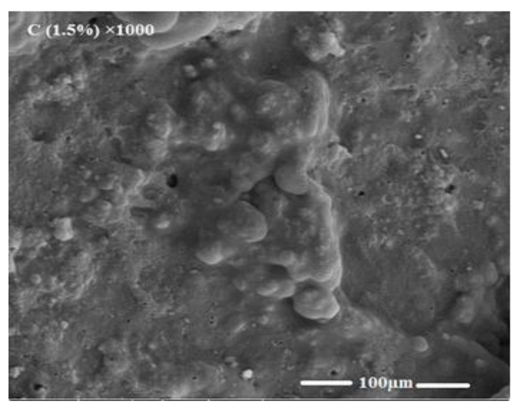

Fig. 4.3. Scanning electron microscopy (SEM) photographs (×1000) of fresh camel milk yoghurt with stabilizer C (1.5%).

Fig. 1, 2, 3 and 4 Scanning electron microscopy (SEM) photographs (× 1000) of fresh camel milk yoghurt with various stabilizers (0.5%, 1.0% and 1.5%), **A**=gelatin E441 and mono & diglyceride of fatty acid E471 (1:1). **B**= guar gum E412, sodium carboxymethyl cellulose E466, and mono & diglyceride of fatty acid E471, (1:1:1). **C**= modified starch E1422 and mono & diglyceride of fatty acid E471 (1:1).

Sensory evaluation:

High concentrations of stabilizers were necessary to prevent the serum separation in camel milk yoghurt. However, in the preliminary sensory assessments, high concentrations of the stabilizers were found to adversely affect the taste of the yoghurt samples providing a foreign taste of their own. Therefore, yoghurt with low and medium concentrations of the stabilizers was presented to the sensory panelists. Stabilizers were found to have a significant effect on taste, odour, consistency and overall acceptability ($p \leq 0.05$). On the other hand, panelists had find differences in the texture of yoghurt samples ($p \leq 0.05$) meaning the textures of the samples with stabilizers particulate material (Table 3). Only guar gum containing yoghurt was noted as giving a ropy texture. The consistencies of the treated samples were found higher than the samples without stabilizer. All samples of yoghurt had similar scores when fresh and the control yoghurt had lower aroma and taste scores compared to treated samples. The added stabilizers of camel milk yoghurt adversely affected the taste and odour. **Lo *et al.* (1996)** reported that guar gum at levels of 0.1–0.5% did not affect the partition coefficients of acetaldehyde, ethanol and diacetyl in acidified milk. A high consistency coefficient was reported to correlate positively with the sensory acceptability of lactic beverages **(Penna *et al.*, 2001)**. **Wendin *et al.* (1997)** reported that sourness in sour milk was masked by pectin and gelatin. Gelatin gave neutral taste and used widely in the textural stabilization of yoghurt **(Fiszman *et al.*, 1999)**. **Güven (1998)** found that gelatin at a concentration of 0.5% increased the viscosity without affecting the taste and the odour in yoghurt.

The scores recorded for body, texture, taste and overall accept ability demonstrated that the addition of stabilizers positively influenced the sensory characteristics in general (Table 3). All stabilizer yoghurts were scored higher on average by the panellists than control yoghurt in terms of aroma and taste (although differences for aroma were not statistically significant), Acetaldehyde for example is recognised as a major flavour component in yoghurt and the presence of lactobacilli in the starter culture can influence the total content of acetaldehyde in final product **(Guler-Akin & Akin, 2007; Ekinci & Gurel, 2008)**. Taste received the lowest scores for all preparations. Colour and appearance of the yoghurt samples was scored most highly for all preparations, while A 1, 1.5% and B 0.5% the various preparations addition of stabilizers resulted in the highest scores for overall sensory attributes **(Koksoy and Kilic, 2004 and Ares, *et al.*, 2007)**. The treatments B 1 and 1.5% which retained the highest rate of water holding capacity had ropiness texture. While, cohesion texture increased in both treatments A and B of camel milk yoghurt.

Table 3: Sensory properties of camel milk yoghurt with stabilizers (0.5%, 1.0% and 1.5%) when fresh and after 21 days of storage.

Characteristic		Treatments										Main effects
		Control	A			B			C			
			0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	
Colour and Appearance (9)	Fresh	6.25±0.75	7.33±0.17	8.42±0.42	8.77±0.23	8.55±0.30	8.33±0.17	8.40±0.15	7.61±0.11	8.55±0.30	8.45±0.20	8.07±0.80^{a}
	21days	5.12±0.88	6.52±0.48	7.33±0.83	8.25±0.15	7.55±0.75	7.45±0.95	7.63±0.38	7.34±0.84	8.14±0.64	8.10±0.60	7.34±1.07^{b}
	Main effects	5.69±0.96^{d}	6.93±0.55^{c}	7.88±0.84^{ab}	8.51±0.33^{a}	8.05±0.75^{ab}	7.89±0.78^{ab}	8.02±0.49^{ab}	7.48±0.56^{bc}	8.35±0.50^{a}	8.28±0.44^{a}	7.70±1.00
Aroma (9)	Fresh	8.23±0.83	8.33±0.33	8.41±0.16	8.59±0.90	8.63±0.07	8.53±0.28	8.45±0.45	8.22±0.28	8.31±0.20	8.11±0.11	8.39±0.33^{a}
	21days	5.41±0.59	7.21±0.61	7.31±0.31	7.68±0.32	7.71±0.79	7.82±0.18	7.75±0.20	7.44±0.56	7.52±0.48	7.45±0.20	7.33±0.79^{b}
	Main effects	6.87±1.72^{b}	7.77±0.75^{a}	7.86±0.64^{a}	8.14±0.54^{a}	8.17±0.71^{a}	8.18±0.44^{a}	8.10±0.57^{a}	7.83±0.58^{a}	7.92±0.54^{a}	7.78±0.39^{a}	7.86±0.81
Body and texture (9)	Fresh	5.12±0.12	7.41±0.59	8.13±0.67	8.53±0.37	7.52±1.18	7.33±0.76	7.21±0.29	7.61±0.39	8.15±0.35	8.52±0.02	7.55±1.06^{a}
	21days	3.31±1.19	6.55±0.45	7.32±0.07	7.53±0.12	7.27±0.73	7.13±0.37	7.07±0.07	7.31±0.69	7.62±0.63	8.11±0.39	6.92±1.37^{b}
	Main effects	4.22±1.25^{e}	6.98±0.66^{d}	7.73±0.62^{abcd}	8.03±0.60^{ab}	7.40±0.89^{bcd}	7.23±0.50^{cd}	7.14±0.20^{cd}	7.46±0.53^{bcd}	7.89±0.54^{abc}	8.23±0.33^{a}	7.24±1.25
Taste(9)	Fresh	6.21±0.79	8.13±0.63	8.17±0.17	7.61±0.64	8.64±0.14	7.82±0.32	7.17±0.17	8.24±0.25	7.46±0.04	7.15±0.10	7.66±0.76^{a}
	21days	4.43±0.44	6.44±0.06	7.34±0.66	7.21±0.29	7.33±0.67	7.44±0.06	6.45±0.55	6.65±0.85	6.51±0.49	6.39±1.11	6.62±0.99^{b}
	Main effects	5.32±1.13^{e}	7.29±1.01^{bcd}	7.76±0.63^{ab}	7.41±0.50^{abcd}	7.99±0.84^{a}	7.63±0.29^{abc}	6.81±0.54^{d}	7.45±1.03^{abcd}	6.99±0.61^{cd}	6.77±0.82^{d}	7.14±1.02
Overall Acceptability (9)	Fresh	6.44±0.56	8.62±0.13	8.74±0.24	8.82±0.02	8.85±0.15	8.17±0.33	7.64±0.36	8.14±0.34	8.26±0.27	8.01±0.51	8.17±0.75^{a}
	21days	4.51±0.01	7.42±0.58	7.56±0.69	8.37±0.35	8.41±0.09	8.04±0.5	6.21±0.23	7.65±0.15	7.52±0.55	7.43±0.93	7.31±1.19^{b}
	Main effects	5.48±1.11^{e}	8.02±0.76^{c}	8.15±0.79^{abc}	8.60±0.34^{ab}	8.63±0.22^{a}	8.11±0.22^{bc}	6.93±0.83^{d}	7.90±0.36^{c}	7.90±0.55^{c}	7.72±0.75^{c}	7.74±1.08
Total scores (45)	Fresh	32.35±1.15	39.82±0.07	41.87±0.32	42.32±1.13	42.19±0.96	40.18±0.57	38.87±0.12	39.82±0.68	40.73±0.37	40.24±0.74	39.84±2.83^{a}
	21days	22.78±2.22	34.14±0.96	36.86±0.14	39.04±0.21	38.27±1.53	37.88±0.38	35.11±0.39	36.39±1.11	37.31±0.44	37.48±0.23	35.53±4.62^{b}
	Main effects	27.57±5.48^{f}	36.98±3.17^{e}	39.37±2.75^{bc}	40.68±1.94^{a}	40.23±2.43^{ab}	39.03±1.33^{cd}	36.99±2.08^{e}	38.11±2.05^{d}	39.02±1.91^{cd}	38.86±1.59^{cd}	37.68±4.38

Mean (±SE). ^{a,b,c} Values in the same row having different superscripts differ significantly ($p < 0.05$)

A=gelatin E441and mono & diglyceride of fatty acid E471 (1:1). **B**= guar gum E412, sodium carboxymethyl cellulose E466 and mono & diglyceride of fatty acid E471 (1:1:1). **C**= modified starch E1422 and mono & diglyceride of fatty acid E471 (1:1).

4. Conclusion

Hydrocolloid stabilizers can be used in camel milk yoghurt to prevent serum separation and to adjust the viscosity. When used at sufficient level, stabilizers reduced the serum separation to negligible levels and increase the viscosity. However, the amounts of the stabilizers that can be used were found to be limited by their effects on the flavour of the product. Treated camel milk yoghurt samples were found to carry an familiar taste and odour to camel milk yoghurt even at low concentrations. In addition, A, B and C stabilizers did not prevent serum separation at low concentrations. Even though A and B provided the highest viscosity and prevented the serum separation in camel milk yoghurt, but it was not preferred organoleptically in B and C (0.5%) due to the ropy texture. Treatment A at a level up to 1.5% is recommended for camel milk yoghurt to stabilize the texture without affecting the flavour of the product.

Acknowledgment

The present document was achieved in the frame of PROCAMED project, supported by the European Union (ENPI-Joint operational Programme of the Mediterranean Basin -IEVP-CT). The contents of this document are the sole responsibility of the 'Division of Animal Production, Animal Breeding Department, Desert Research Center (Egypt) and can under no circumstances be regarded as reflecting the position of the European Union.

References

1. AOAC, (2005). Association of Official Agricultural Chemists. Official Methods of Analysis, 18th ed., Washington, DC.
2. Ares, G.; Gonçalvez, D.; Pérez, C.; Reolón, G.; Segura, A.; Lema, P. and Gámbaro, A. (2007). Influence of gelatin and starch on the instrumental and sensory texture of stirred yogurt. Int. J. Dairy Technol., 60, 263-296.
3. Barbut, S. (1999). Determining water and fat holding. In G. M. Hall (Ed.), Methods of testing protein functionality. New York: Blackie Academic and Professional. (pp. 186–225)
4. Bourriot, S.; Garnier, C., and Doublier, J. L. (1999). Phase separation, rheology and structure of micellar casein–galactomannan mixtures. Int. Dairy J., 9, 353–357.
5. Dave, R. I., and Shah, N. P. (1997a). Effect of cysteine on the viability of yoghurt and probiotic bacteria in yoghurts made with commercial starter cultures. Int. Dairy J., 7, 537–545.
6. Dave, R. I., and Shah, N. P. (1997b). Viability of yoghurt and probiotic bacteria in yoghurts made from commercial starter cultures. Int. Dairy J., 7(1), 31–41.
7. Dickinson, E. (1992). An Introduction to Food Colloids, Oxford, Oxford University Press.
8. Dickinson, E. (1998). Stability and rhelogical properties implications of electrostatic milk protein-polysaccharide interactions. Trends in Food Sci. and Technol., 9, 347–354.
9. Duboc, P., and Mollet, B. (2001). Application of exopolysaccharides in the dairy industry. Int. Dairy J., 11, 759–768.
10. Edwards, C. A. and Garcia, A. L. (2009). The health aspects of hydrocolloids. Chapter three from Handbook of hydrocolloids. Second edition, Woodhead Publishing India Private Limited, G-2, Vardaan House, 7/28 Ansari Road, Daryaganj, New Delhi - 110002, India.
11. Ekinci, F. Y., and Gurel, M. (2008). Effect of using propionic acid bacteria as an adjunct culture in yogurt production. J. of Dairy Sci., 91, 892–899.
12. Ellis, P. R., Apling, E. C., Leeds, A. R., Peterson, D. B. and Jepson, E. M. (1985), `Guar bread and satiety: effects of an acceptable new product in overweight diabetic patients and normal subjects. J. Plant Foods, 6, 4, 253-262.
13. Fiszman, S. M., and Salvador, A. (1999). Effect of gelatine on the texture of yoghurt and of acid-heat-induced milk gels. Zeitschrift für Lebensmittel Untersuchung und Forschung A, 208, 100–105.
14. Fiszman, S. M., Lluch, M. A., and Salvador, A. (1999). Effect of addition of gelatine on microstructure of acidic milk gels and yoghurt and on their rheological properties. Int. Dairy J., 9, 895–901.
15. Foss, J. W. (2000). How processing affects starch selection for yoghurt. Bridgewater, NJ: National Starch and Chemical Company.
16. Fox, J. E., Ingenpass, P., and Zachow, S. (1993). Stabilizers. In R. Macrae (Ed.), (Vol. 7). Encyclopaedia of food science, food technology, and nutrition, London: Academic Press. pp. 4350–4358.
17. Güven, M. (1998). Effects of stabilizer usage on some quality characteristics of yoghurt. Gida, 23, 133–139.
18. Guinee, T. P., Mullins, C. G., Reville, W. J., and Cotter, M. P. (1995). Physical properties of stirred-curd unsweetened yoghurts stabilised with different dairy ingredients. Milchwissenschaft, 50, 196–200.
19. Guler-Akin, M. B., and Akin, M. S. (2007). Effects of cysteine and different incubation temperatures on the microflora, chemical composition and sensory characteristics of bio-yogurt made from goat's milk. Food Chem., 100, 788–793.
20. International Dairy Federation (IDF), (1982). Cheese and Processed Cheese Determination of Total Solids Content (Reference Methods). IDF Standard 4A.
21. Isanga, J., and Zhang, G. (2009). Production and evaluation of some physicochemical parameters of peanut milk yoghurt. LWT – Food Sci. and Technol., 42, 1132–1138.

22. Kailasapathy, K., Harmstorf, I., and Phillips, M. (2008). Survival of *Lactobacillus acidophilus* and *Bifidobacterium animalis* ssp. *lactis* in stirred fruit yogurts. LWT- Food. Sci. and Technol., 41, 1317–1322.
23. Keogh, M. K., & O'Kennedy, B. T. (1998). Rheology of stirred yogurt as affected by added milk fat, protein and hydrocolloids. J. of Food Sci., 63, 108–112.
24. Koksoy, A. and Kilic, M. (2004). Use of hydrocolloids in textural stabilization of a yoghurt drink, ayran. Food Hydrocolloids, 18, 593–600.
25. Kroger, M. (1975). Quality of yoghurt. J. of Dairy Sci. 59 344–350.
26. Ling, E.R. (1963). A textbook of dairy chemistry. (2) Practical 3rd. Chapman and Hill.
27. Lo, C. G., Lee, K. D., Richter, R. L., and Dill, C. W. (1996). Dairy foods, influence of guar gum on the distribution of some flavor compounds in acidified milk products. J. of Dairy Sci., 79, 2081–2090.
28. Lorenzen, P. C., Neve, H., Mautner, A., and Schlimme, E. (2002). Effect of enzymatic cross-linking of milk proteins on functional properties of set-style yoghurt. International J. of Dairy Technol., 55, 152-157.
29. Lucey, J. A., Tamehana, M., Singh, H., and Munro, P. A. (1999). Stability of model acid milk beverage: effect of pectin concentration, storage temperature and milk heat treatment. J. Texture Studies, 30, 305–318.
30. Martin-Diana, A. B., Janer, C., Pelaez, C., and Requena, T. (2003). Development of a fermented goat's milk containing probiotic bacteria. Int. Dairy J., 13, 827–833.
31. Mehanna, N. M., Ibrahim, E. M., El-Nawasany, L. I. (2013). Impact of some hydrocolloids on the physical characteristics and quality of non-fat yoghurt. Egyptian J. Dairy Sci., 41,163-170.
32. Okoth, E. M.; Kinyanjui, P. K.; Kinyuru, J. N. and Juma,F. O. (2011). Effects of substituting skimmed milk powder with modified starch in yoghurt production. Jomo Kenyatta Uni. of Agric. and Technol., 13, 25-32.
33. Penna, A. L. B., Sivieri, K., & Oliviera, M. N. (2001). Relation between quality and rheological properties of lactic beverages. J. Food Eng., 49, 7–13.
34. Phillips, G. O. and Williams, P. A. (2009). Handbook of hydrocolloids. Second edition, Woodhead Publishing India Private Limited, G-2, Vardaan House, 7/28 Ansari Road, Daryaganj, New Delhi - 110002, India.
35. Puvanenthiran, A.; Williams, R. and Augustin, M. (2002).Structure and viscoelastic properties of set yoghurt with altered casein to whey protein ratios. Int. Dairy J., 12, 383–391.
36. Ranadheera, S.; Evans, C.A.; Adams, M.C.; Baines, S.K. (2012). Probiotic viability and physico-chemical and sensory properties of plain and stirred fruit yogurts made from goat's milk. . Food Chem., 135, 1411–1418.
37. Schmidt, K. A., and Smith, D. E. (1992). Rheological properties of gum and milk protein interactions. J. Dairy Sci., 75, 36–42.
38. Staff, M. C. (1998). Cultured milk and fresh cheese. In R. Early (Ed.), The technology of dairy products. New York: Chapman and Hall. (pp. 123–157)
39. Syrbe, A., Bauer, W. J., and Klostermeyer, H. (1998). Polymer science concepts in dairy systems-an overview of milk protein and food hydrocolloid interaction. Int. Dairy J., 8, 179–193.
40. Tamime, A. Y., and Robinson, R. K. (1999). Yogurt Science and Technology. Cambridge: Woodhead Publishing Ltd.
41. Thaiudom, S., and Goff, H. D. (2003). Effect of k-carrageenan on milk protein polysaccharide mixtures. Int. Dairy J., 13, 763–771.
42. Towler, C. (1984). Sedimentation in a cultured milk beverage. New Zealand J. of Dairy Sci. and Technol., 19, 205–211.
43. Vinderola, C. G., Bailo, N., and Reinheimer, J. A. (2000). Survival of probiotic microflora in Argentinian yoghurts during refrigerated storage. Food Res. Int., 33, 97–102.
44. Wang, W., Bao, Y., Hendricks, G. and Guo, M. (2012). Consistency, microstructure and probiotic survivability of goats' milk yoghurt using polymerized whey protein as a co-thickening agent. Int. Dairy J. 24, 113-119.
45. Wendin, K., Solheim, R., Allmere, T., and Johansson, L. (1997). Flavour and texture in sourmilk affected by thickeners and fat content. Food Quality and Preference, 8, 281–291.
46. Wu, H., Hulbert, G. J., and Mount, J. R. (2001). Effects of ultrasound on milk homogenization and fermentation with yogurt starter. Innovative Food Science and Emerging Technologies, 1, 211–218.

12/20/2014