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INFLUENCE OF ADDITION MODIFIED STARCHES AS STABILIZER ON PHYSICOCHEMICAL AND TEXTURAL PROPERTIES OF CAMEL'S MILK YOGHURT

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ABSTRACT

The objective of this study was to estimate the effect of addition of modified starch (1, 2, 3, 4 and 5%, w/w) on camel's milk yoghurt during cold storage. Major component, water holding capacity (WHC), susceptibility to syneresis (STS) and viscosity were determined. Moreover, the changes in microstructure and sensory properties were evaluated. Addition of modified starch significantly ($p \leq 0.05$) decreased the syneresis, whereas increased significantly ($p \leq 0.05$) viscosity and water holding capacity of camel's milk yoghurt ($p \leq 0.05$), in addition, enhanced their sensory acceptability. The addition rate of modified starch had significant effect on acidity and total solids of camel's milk yoghurt. The water holding capacity and susceptibility to syneresis of camel's milk yoghurt were significantly ($p \leq 0.05$) affected by the quantity of modified starch. The optimum results were recorded using the addition rate at 3%. Increasing the amount of the modified starch added, resulted in increasing water holding capacity and lower susceptibility to syneresis values. Addition of modified starch caused the lowest acidity and the highest pH value of camel's milk yoghurt compared to control. The modified starch treated camel's milk yoghurt had higher total solids, protein and fat than the control. The images of scanning electron microscopy (SEM) showed that the modified starch occupied the void space within casein particle network. Treated camel's 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 modified starch to camel's milk yoghurt lead to the merger of casein micelles with each other, which increases the cohesion flat casein compared with a control sample. Camel's milk yoghurt with 3% modified starch gained the highest sensory score compared to the corresponding treatments. It could be concluded that the addition of modified starch can improve the chemical, sensory and microstructure properties of set camel's milk yoghurt. Camel's milk yoghurt with 3% modified starches is recommended to improve the body and texture without affecting the overall acceptability of the product.

Key words: Modified starch, sensory evaluation, camel's milk yoghurt, microstructure.

INTRODUCTION

Rheological properties of yoghurt are known to be influenced by several factors during processing, the milk constituency itself (protein content, additives), the type of culture (ropy or non ropy), heat treatment and mechanical processes undergoes after fermentation. The mechanical processes include stirring, pumping through pipes and filling which exposes it to shear resulting in a viscosity decrease. Rheological and stability properties of yoghurt can be modified by fortifying the milk with dairy – based ingredients, non-dairy ingredients or a combination of both prior to heat treatment and acidification (Oh *et al.*, 2007). Non-dairy additives like polysaccharides such as starches can be used in yoghurt in

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conjunction with dairy ingredients or on their own to modify the rheological properties. Yoghurts made from different starches exhibit different rates of viscosity *e.g.* wheat starch showed highest shear consistency compared to other varieties (Keogh and O'Kennedy, 1998). In contrast, starch 'gelatinize' when heated in the presence of water, with the critical temperature dependent on the type of starch. Starch gelatinisation encompasses disruption of the granular structure, swelling and hydration, and solubilization of starch molecules. Swelling is accompanied by leaching of granule constituents, mostly amylose, and the formation of a three dimensional network in the serum. The swelling that develops in such a mixed system of milk and starch during heat treatment may lead to different rheological characteristics in the final yoghurt gel and consequently in the stirred yoghurt product compared to that made from milk alone (Narpinder *et al.*, 2003). The swelling property of starch is depended on its amylopectin content, amylose acts both as a diluent and inhibitor of swelling (Tester and Morrison, 1990). Starch exhibits unique viscosity behavior with change in temperature, concentration and shear rate (Nuruli and Azemi, 1990). Starch behavior in a system like that one of yoghurt, will also depend on their physical and chemical characteristics, such as mean granule size distribution, amylase/amylopectin ratio and mineral content. Rheological characteristics of casein gels depend on the number and strength of the bonds between the casein particles, on its structure and the special distribution of the strands making up these particles (Roefs *et al.*, 1990). Chemically modified starches, that also qualify as resistant starches (RS), have an important role in human health, and withstand gelatinization (granule swelling) under most heating regimes have been recently targeted for use in food products (Fuentes-Zaragoza *et al.*, 2011). Apart from the potential health benefits of RS, it impacts minimally the sensory properties of food compared with traditional sources of fibre such as whole grains, fruits or bran. In practice, milk-based proteins such as skimmed milk powder, whey proteins and caseins are often used in yoghurt to improve its viscosity and stability. However, starch gives a cheaper product than these milk based additives. Further, modified starch is not widely used though it is expected to have a better output as compared to the non-modified starch commonly used in yoghurt production. Among the desirable physicochemical properties of starches are their viscosity, gel formation ability and water-binding capacity which make them useful in a variety of foods. There is scant information regarding the application of RS in dairy products (Duggan *et al.*, 2008; Noronha *et al.*, 2008). It is one of the most frequently used thickening agents in yoghurt production due to its processing ease and low cost when compared to other hydrocolloids (Foss, 2005).

The objective of this work was determined to using different concentrations of modified starch in the production of camel's milk yoghurt on physicochemical, microstructure and sensory characteristics of final product.

MATERIALS AND METHODS

Camel's Milk

Fresh whole camel's milk from healthy and uninfected Magrabi camels's (*Camelus dromedarius*) was obtained from Sidi-Barani areas, Matrouh Governorate, North West Coast of Alexandria city, Egypt.

Stabilizer

Modified starch, E1422 (Acetylated distarch adipate), was obtained from the Egyptian Company for Dairy Products and Food Additives "EGY- DAIRY " (10^{th} of Ramadan city, Sharkia Governorate, 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.

Manufacture of Camel's Milk Yoghurt

Modified starch, E1422 was added at ratio 1, 2, 3, 4 and 5% (w/w) to fresh camel's milk. In addition, camel's milk without additives was served as control. The milk was then homogenized at 60° C, 400Kpa. The untreated and stabilizers treated camel's 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 3 weeks.

Chemical Analysis

According to AOAC (2005), yoghurt samples were chemically analysed. Protein was determined using micro Kjeldahl method (TN × 6.38), fat and titratable acidity (as lactic acid %). pH values were determined as described by Ling (1963). Total solids were measured according to IDF (1982).

Rheological Analysis

Viscosity of the samples (centipoises cP) was measured as described by Ranadheera *et al.* (2012). The yoghurt susceptibility to syneresis (STS) and water holding capacity (WHC) were determined according to the methods reported by Isanga and Zhang (2009).

Scanning Electron Microscopy (SEM)

Samples of yoghurt were prepared 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 taste panellists, when fresh and weekly up to 3 weeks. The panellists were asked to evaluate the colour and appearance, aroma, body and texture, taste and overall acceptability when fresh and after 1, 2 and 3 weeks of storage, based on a 9 point as described by Ranadheera *et al.* (2012).

Statistical Analysis

The data were analyzed by ANOVA according to the appropriate experimental designs and reported as means (±standard deviations), which were separated by Duncan's New Multiple Range Test at $p \leq 0.05$ (Cochran and Cox, 1992) and least significant difference (LSD) test using SPSS computer program, version 16.0 (SPSS Inc., Chicago, IL, USA). All analyses and measurements were repeated in triplicates.

RESULTS AND DISCUSSION

Chemical Characteristics

The obtained results in Table 1 indicate that the initial titratable acidity and pH value of the fresh camel's milk yoghurt with modified starch were 0.64%-0.84 % and 4.54-4.86 respectively, as compared with control samples 0.82% and 4.58. The titratable acidity of camel's milk yoghurt with modified starch and control samples had increased to 0.67-0.87 and 0.91 % after 3 weeks respectively, (Table1). The pH of samples with or without modified starch were reduced to 4.41- 4.79 and 4.24 after 3 weeks. Lower acidity of the fresh yoghurt with modified starch was obtained compared with control yoghurt samples. However, it was noticed the decrease of the acidity (%) with the increase of the added per cent of modified starch in all camel's milk yoghurt samples. Further, increasing of acidity and declines in the pH of all types of yogurts with the advance of the storage period was recorded (Table 1). Generally, starch addition resulted in lower acidity of yoghurts during cold storage. Post-acidification during storage can be linked to the progressive transformation of lactose into lactic acid (Ramírez-Santiago *et al.*, 2010). This effect could be attributed to an enhanced growth and survival of probiotic bacteria, which probably induced a more rapid transformation of lactose into lactic acid. Decreased titration acidity with increasing the concentration of modified yoghurt may be due to decreased of viable total bacteria counts when the higher concentration of modified starches led to marked increases in viscosity and pH. There were significant ($p \leq 0.05$) differences in pH between control yoghurt and all of the camel's milk yoghurts at the end of the storage. The pH value decline may be due to continued fermentation by the lactic acid bacteria.

Table 1. Chemical characteristics of camel's milk yoghurt made with modified starch during storage at 5±2°C for three weeks

Parameter	Storage period (week)	Control	1%	2%	3%	4%	5%	Main effects	LSD
Titratable acidity (%)	Fresh	0.82±0.03^{ab}	0.84±0.03^{a}	0.81±0.06^{ab}	0.78±0.06^{ab}	0.73±0.11^{ab}	0.64±0.19^{b}	0.77±0.12^{A}	0.17
	1	0.86±0.05^{a}	0.85±0.04^{a}	0.82±0.05^{ab}	0.80±0.04^{ab}	0.74±0.10^{ab}	0.65±0.18^{b}	0.79±0.12^{A}	0.16
	2	0.88±0.06^{a}	0.86±0.05^{a}	0.83±0.04^{a}	0.81±0.03^{ab}	0.75±0.09^{ab}	0.66±0.17^{b}	0.80±0.11^{A}	0.15
	3	0.91±0.01^{a}	0.87±0.01^{a}	0.84±0.03^{ab}	0.82±0.09^{ab}	0.76±0.11^{ab}	0.67±0.17^{b}	0.81±0.11^{A}	0.16
	Main effects	0.86±0.05^{a}	0.85±0.03^{a}	0.83±0.04^{a}	0.81±0.05^{ab}	0.75±0.09^{b}	0.66±0.15^{c}	0.79±0.10	0.066
pH value	Fresh	4.58±0.03^{b}	4.54±0.03^{b}	4.59±0.09^{ab}	4.62±0.04^{ab}	4.77±0.26^{ab}	4.86±0.21^{a}	4.66±0.16^{A}	0.25
	1	4.42±3.60^{a}	4.48±3.67^{a}	4.54±3.67^{a}	4.58±3.74^{a}	4.75±3.91^{a}	4.84±4.01^{a}	4.60±3.17^{A}	6.70
	2	4.39±3.57^{a}	4.43±3.62^{a}	4.51±3.64^{a}	4.54±3.70^{a}	4.71±3.87^{a}	4.82±3.99^{a}	4.56±3.14^{A}	6.64
	3	4.24±0.20^{b}	4.41±0.08^{ab}	4.49±0.25^{ab}	4.52±0.01^{ab}	4.68±0.20^{a}	4.79±0.38^{a}	4.52±0.26^{A}	0.39
	Main effects	4.41±2.17^{a}	4.46±2.20^{a}	4.53±2.21^{a}	4.56±2.24^{a}	4.72±2.35^{a}	4.81±2.41^{a}	4.58±2.18	1.84
Total solids (%)	Fresh	13.87±0.42^{a}	14.95±1.29^{a}	15.98±0.10^{a}	17.21±2.09^{a}	18.31±4.44^{a}	19.67±5.12^{a}	16.66±3.22^{A}	5.30
	1	14.29±0.24^{f}	15.23±0.10^{e}	16.12±0.44^{d}	17.35±0.24^{c}	18.56±0.44^{b}	19.88±0.64^{a}	16.90±1.99^{A}	0.69
	2	14.86±0.38^{f}	15.65±0.60^{e}	16.55±0.30^{d}	17.78±0.67^{c}	18.91±0.11^{b}	19.94±0.39^{a}	17.28±1.85^{A}	0.67
	3	15.21±0.18^{a}	15.85±1.60a	16.73±2.65^{a}	17.96±2.94^{a}	19.01±3.79^{a}	20.21±5.95^{a}	17.49±3.35^{A}	5.99
	Main effects	14.55±0.60^{e}	15.42±0.95^{de}	16.34±1.28^{cd}	17.57±1.59b^{c}	18.69±2.51^{ab}	19.92±3.36^{a}	17.08±2.65	1.60
Protein (%)	Fresh	3.34±0.10^{a}	3.41±0.25^{a}	3.48±0.06^{a}	3.43±0.45^{a}	3.45±0.44^{a}	3.46±0.45^{a}	3.42±0.29^{A}	0.59
	1	3.36±2.54^{a}	3.43±2.62^{a}	3.42±2.55^{a}	3.46±2.62^{a}	3.48±2.64^{a}	3.49±2.66^{a}	3.44±2.20^{A}	4.63
	2	3.37±2.55^{a}	3.45±2.64^{a}	3.43±2.56^{a}	3.47±2.63^{a}	3.47±2.67^{a}	3.42±2.59^{a}	3.43±2.18^{A}	4.61
	3	3.39±0.15^{a}	3.48±0.57^{a}	3.44±0.68^{a}	3.49±0.50^{a}	3.42±0.12^{a}	3.45±0.22^{a}	0.46±0.37^{A}	0.77
	Main effects	3.36±1.53^{a}	3.44±1.60^{a}	3.44±1.56^{a}	3.46±1.61^{a}	3.45±1.60^{a}	3.46±1.58^{a}	3.44±1.53	1.29
Fat (%)	Fresh	3.19±0.31^{a}	3.21±0.19^{a}	3.23±0.37^{a}	3.24±0.46^{a}	3.25±0.25^{a}	3.25±0.15a	3.22±0.26^{A}	0.55
	1	3.21±2.39^{a}	3.22±2.41^{a}	3.25±2.38^{a}	3.27±2.43^{a}	3.27±1.41^{a}	3.28±2.43^{a}	3.25±2.03^{A}	4.29
	2	3.23±2.41^{a}	3.24±2.43^{a}	3.26±2.39^{a}	3.29±2.45^{a}	3.29±2.41^{a}	3.31±2.48^{a}	3.27±2.05^{A}	4.33
	3	3.27±0.43^{a}	3.25±0.15^{a}	3.27±0.33^{a}	3.31±0.90^{a}	3.33±0.47^{a}	3.34±0.36^{a}	3.30±0.28^{A}	0.60
	Main effects	3.22±1.46^{a}	3.24±1.48^{a}	3.25±1.45^{a}	3.27±1.48^{a}	3.28±1.49^{a}	3.29±1.50^{a}	3.26±1.42	1.20

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($p \leq 0.05$).

Protein and fat contents were found to be slight high in yoghurts with modified starch, compared with control yoghurts. High total solids content in treated yoghurts may be due to addition of modified starch (Table 1). Changes in these parameters, especially total solids may affect certain other physiochemical properties such as syneresis, water holding capacity and viscosity.

Rheological Properties

Water holding capacity

As shown from Table 2, the water holding capacity (WHC %) of yoghurts with modified starch was significantly ($P \leq 0.05$) higher than that of the control samples. Samples produced with 3-5% modified starch had higher level of water holding capacity and did not show syneresis. The difference in WHC of the yoghurts may be attributed to the properties of the different total solids 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).

Wu *et al.* (2001) demonstrated that 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 the present study, yoghurts with added modified starch demonstrated significantly higher water holding capacity compared to control yoghurts, possibly reflecting the higher total solids of the treated yoghurt compared to control yoghurt (Table 2). In addition, modified starch influenced higher level of water holding capacity.

Stabilizers have two basic functions in yoghurt *i.e.*, the binding of water and improvement in texture (Thaiudom and 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 and Robinson, 1999; Duboc and Mollet, 2001).

Waliszewski *et al.* (2003) reported that modified banana starches exhibited a better water binding than native starch because hydrophilic groups were incorporated. Han *et al.* (2005) found that hydroxypropylated waxy rice and corn starches (molar substitutions 0.13 and 0.11, respectively) had higher water- holding capacity than the unmodified starches.

Susceptibility to syneresis

The susceptibility to syneresis (STS%) of yoghurts with added modified starch was significantly ($P \leq 0.05$) lower than that of control samples. The lower STS of samples with modified starch than the control samples may be explained by the higher total solids content of treated samples compared to control (Table 2). Syneresis, an undesirable property in yoghurt products, is the effect of liquid separating from the yoghurt curd (Wu *et al.*, 2001). It was earlier reported by 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 and O'Kennedy, 1998). Similar results was reported by Kebary *et al.* (2004) when the modified starch were added to yoghurt, serum separation was reduced compared to that in yoghurt without modified starch. The reduction of serum separation to zero was possible when high concentrations (>3%) was used. Guinee *et al.* (1995) reported that the use of modified starch at a level of 1.5 % reduced syneresis but did not prevent serum separation in yoghurts. Ares *et al.* (2007) showed that the stirred yoghurt manufactured with the addition of (1 mg/g milk) of starch showed the same syneresis values as the control sample. However, the addition of (5 or 10 mg/g milk) of starch reduced syneresis by 18%.

Serum separation occurs in fermented milk products due to the aggregation and sedimentation of casein particles during storage. The use of the modified starch was found to be necessary to prevent serum separation in fermented milk. Spontaneous whey separation is related to an unstable network, which can be due to an increase in the rearrangement of the gel matrix, and besides affects negatively consumer perception of yogurt, that think there is something wrong with the product. Starches have been used to achieve fat mimetic properties by retaining substantial quantities of water into weak gel structures (Luo and Gao, 2011). Lobato-Calleros, *et al.* (2014) studied the impact of adding chemically modified starch as fat replacers in the rheological properties of yogurt. It was found that chemically modified starch can induce positive impact in syneresis, flow and viscoelastic properties as compared with a full-fat yogurt by contributing to the formation of more stable milk gels.

Viscosity

The viscosity of camel's milk yoghurt had increased significantly ($p \leq 0.05$) by the use of modified starch in camel's milk yoghurt (Table 2). Samples containing 3-5% modified starch showed the highest viscosity compared to the corresponding treatments. 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. Polysaccharide gums increase viscosity in dispersions by nonspecific entanglement preventing the interactions of dispersed particles (Fox *et al.*, 1993). Low level of modified starch might not cover all the casein particles and create sufficient electrostatic and steric repulsions to stabilize the dispersion (Dickinson, 1998; Syrbe *et al.*, 1998; Ibrahim and Khalifa, 2015). The viscosity of camel's milk yoghurt had increased with increasing concentrations of added modified starch (Table 2). Starch preparations added to yoghurt milk form polysaccharide matrix inside protein gel, that makes final product more shock-resistant, enhances viscosity and gel strength (Robinson and Tamime, 1994; Najgebauer-Lejko *et al.*, 2007). Williams *et al.* (2003, 2004) reported that the addition of modified waxy corn starch to yoghurt made from only skim milk solids increased the viscosity, but developed a grainy texture. The viscosity of yoghurt with modified starch 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 Isanga and Zhang (2009), Ibrahim and Khalifa (2015). Isanga and Zhang (2009) reported that high levels of fat might 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.

Overall, the results in Table 2 suggest that the addition of modified starch increased water-holding capacity as well as yoghurt stability during storage. The highest viscosity in camel's milk yoghurt was obtained by treatments 3-5% modified starch. It has been shown that modified starch can form composites with proteins, leading to significant syneresis reduction (Singh and Byars, 2009). Also, whey protein and starch can form interpenetrating continuous network that enhance the ability of water retaining (Considine *et al.*, 2011). The increase of viscosity in camel's milk yoghurt containing different ratios of modified starch may be due to the interaction between the modified starch and casein particles thus contributing a strong gel when the concentration was doubled (Koksoy and Kilic, 2004 ; Ibrahim and Khalifa, 2015).

Microstructure of camel's milk yoghurt

The microstructure of set-style camel's milk yoghurt as affected by the addition of modified starch are shown in Fig. 1. Microstructure analysis demonstrated that the internal structure of camel's milk yoghurt formulated with modified starch was smooth and dense than the surfaces of control samples (Fig. 1). The control camel's milk yoghurt showed rough, coarse and granular outer surfaces. By comparison, the camel's milk yoghurt with modified starch had denser, smoother structures. These structural features may be associated with the textural attributes of the product. Hence, it can be hypothesized that the control sample induced a more interspersed and heterogeneous structure due to protein or fat non-integrated.

Treated yoghurts with modified starch 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

Table 2. Water holding capacity (WHC %), susceptibility to syneresis (STS %) and viscosity (cp) of camel's milk yoghurt made with modified starch during storage at 5±2°C for three weeks

Parameter	Storage period (week)	Control	1%	2%	3%	4%	5%	Main effects	LSD
WHC (%)	Fresh	46.96±3.27^{d}	69.34±8.09^{c}	86.26±4.90^{b}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	83.76±20.69^{A}	7.27
	1	43.34±42.52^{a}	68.44±67.63^{a}	85.31±84.44^{a}	100±0.00^{a}	100±0.00^{a}	100±0.00^{a}	82.84±45.37^{A}	84.42
	2	42.14±41.32^{a}	67.34±66.53^{a}	84.56±83.69^{a}	98.21±97.37^{a}	100±0.00^{a}	100±0.00^{a}	82.04±56.04^{A}	109.22
	3	41.21±7.02^{d}	66.14±10.72^{c}	83.64±5.75^{b}	96.72±1.50^{a}	97.21±0.88^{a}	98.41±0.16^{a}	80.55±22.06^{A}	10.28
	Main effects	43.41±25.59^{c}	67.82±40.87^{bc}	84.94±50.81^{ab}	98.73±41.54^{a}	99.30±1.31^{a}	99.60±0.72^{a}	82.30±38.28	27.11
STS (%)	Fresh	36.86±3.35^{a}	9.66±1.52^{b}	6.36±2.65^{c}	0.00^{d}	0.00^{d}	0.00^{d}	8.81±13.54^{C}	3.29
	1	38.14±7.07^{a}	10.25±1.75^{b}	7.45±1.12^{b}	0.00^{c}	0.00^{c}	0.00^{c}	9.31±14.13^{BC}	5.35
	2	41.25±5.03^{a}	11.68±1.38^{b}	8.35±0.83^{b}	2.21±0.91^{c}	0.00^{c}	0.00^{c}	10.58±14.91^{B}	3.89
	3	42.31±1.06^{a}	12.12±0.87^{b}	9.55±1.03^{c}	4.11±0.90^{d}	3.35±0.99^{de}	2.10±0.74^{e}	12.25±14.33^{A}	1.67
	Main effects	39.64±4.61^{a}	10.92±1.60^{b}	7.92±1.82^{c}	1.58±1.87^{d}	0.83±1.57^{d}	0.52±1.00^{d}	10.24±13.99	1.95
Viscosity (cP)	Fresh	330±35^{e}	942±86^{e}	2421±267^{d}	6356±191^{c}	9832±126^{b}	25036±1505^{a}	7486±8772^{A}	1124.50
	1	337±61^{e}	1011±108^{e}	2434±65^{d}	6389±825^{c}	9869±5^{b}	25141±1213^{a}	7530±8797^{A}	1070.26
	2	339±19^{e}	1037±88^{e}	2486±98^{d}	6414±998^{c}	9951±77^{b}	25214±1334^{a}	7573±8821^{A}	1215.11
	3	332±20^{d}	1039±172^{d}	2491±410^{d}	6422±869^{c}	9963±1223^{b}	25231±3121^{a}	7579±8893^{A}	2535.72
	Main effects	334±32^{f}	1007±113^{e}	2458±203^{d}	6395±677^{c}	9903±525^{b}	25155±1658^{a}	7542±8632	628.98

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($p \leq 0.05$).

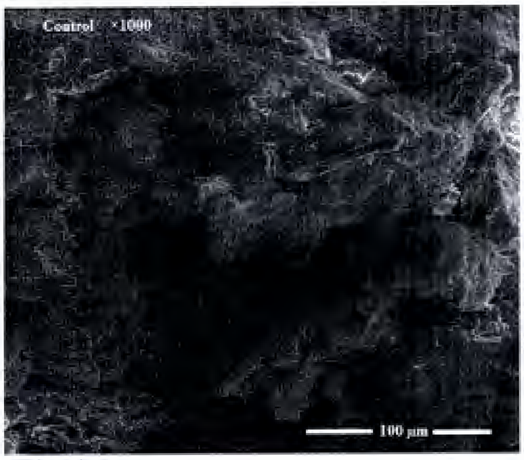

Fig. 1,1.

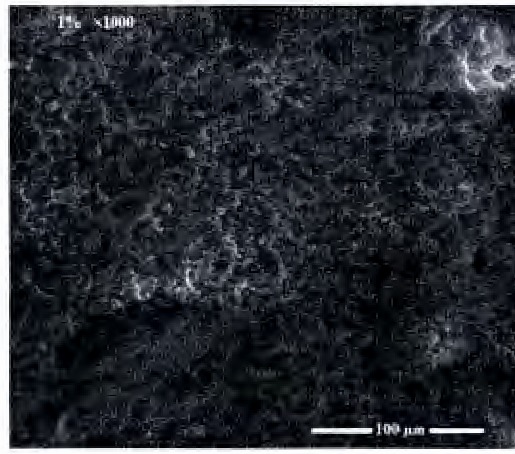

Fig. 1,2.

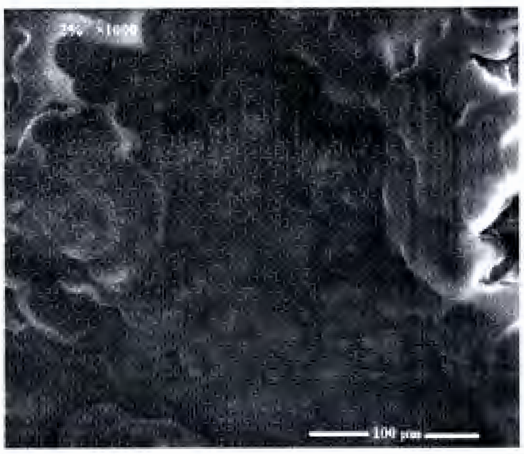

Fig. 1,3.

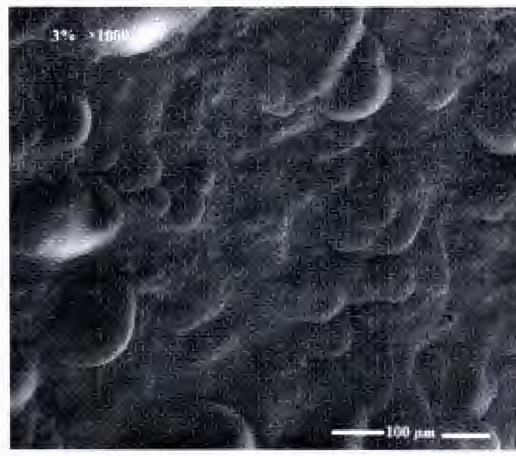

Fig. 1,4.

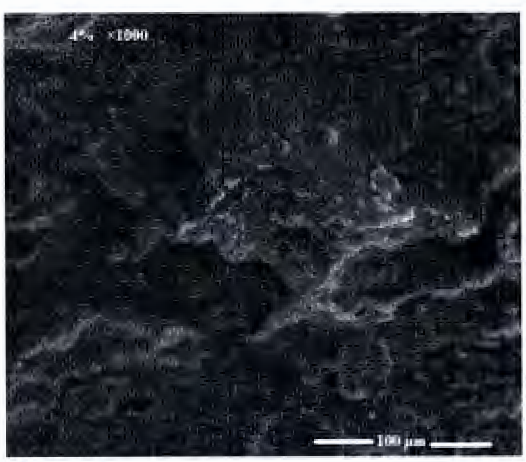

Fig. 1,5.

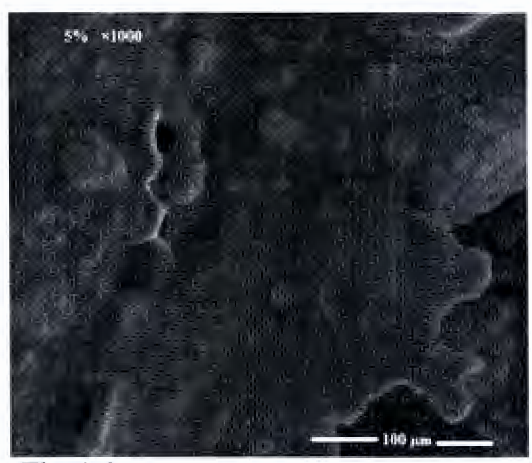

Fig. 1,6.

Fig. 1. Scanning electron microscopy (SEM) images of fresh camel's milk yoghurt with modified starch (1=control, 2=1%, 3=2%, 4=3%, 5=4% and 6=5% modified starch)

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's 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. 1,1). Tamime and Robinson, (1999) reported that, in typical scanning electron micrographs of yoghurt with stabilizers, a casein matrix is visible with various forms and sizes of compact area. The casein matrix appears as closely packed lumps direly granulated more (Figs. 1, 2, 3 and 4). SEM of fresh camel's milk yoghurt with modified starch 4-5%, casein matrix appear of granular shape as in chemical analysis with more water holding capacity. A hardness appearance due to the high WHC 100% (Figs. 1, 5 and 6), while in samples with 4 and 5% of modified starch (WHC, 100%) the highest addition of modified starch led to more compact gels (Figs.1,5 and 6). Scanning electron microscopy of fresh camel's milk yoghurt with modified starch Fig.1:, 3 and 4, reflected the compact structure of casein network with less water holding capacity than treatment with 1% modified starch. The addition of modified starch to camel's milk yoghurt to the merger of casein micelles with each other, which increases the cohesion flat casein compared with a control sample. The treatment 4-5% modified starch which retained the highest rate of water holding capacity had higher hardness textures, while cohesion textures increased in both treatment 2 and 3% of camel's milk yoghurt.

Sensory evaluation

Means scores (±SD) of sensory evaluation for set camel's milk yoghurt as affected by the addition of modified starch compared with that of control during storage period are shown in Table 3. High concentrations of modified starch were necessary to prevent the serum separation in camel's milk yoghurt. However, in the preliminary sensory assessments, high concentrations of the modified starch were found to affect the taste of the yoghurt samples providing a foreign taste of their own. Therefore, yoghurt with low and medium concentrations of the modified starch were presented to the sensory panelists. Modified starch had 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 modified starch particulate material (Table 3). Only 4-5% modified starch in yoghurt had noted as giving a higher hardness textures. The consistency of the treated samples was found higher than the samples without modified starch. All samples of yoghurt had similar score when fresh and the control yoghurt had lower aroma and taste scores compared to treated samples. The added modified starch of yoghurt camel's milk adversely affected the taste and odour. Ibrahim and Khalifa (2015) found that modified starch at a concentration of 1.5% increased the viscosity without affecting the taste and the odour in camel's milk yoghurt. Starch additives promote also flavour holding, limit whey separation and additionally improve sensory properties and dietetic value of the final products (Robinson and Tamime, 1994; Najgebauer-Lejko *et al.*, 2007).

The scores recorded for body, texture, taste and overall accept ability demonstrated that the addition of modified starch positively influenced the sensory characteristics in general (Table 3). All yoghurts with modified starch had higher scores on average by the panellists than control yoghurt in terms of aroma and taste (although differences for aroma were not statistically significant). Colour and appearance of the yoghurt samples was scored most highly for all preparations, while the treatments with 2 and 3% modified starch gained the highest scores for overall sensory attributes.

Conclusion

The results of present study suggest that the modified starch could be used as stabilizer in camel's milk yoghurt to prevent serum separation and to adjust the viscosity. When used at sufficient level, modified starch reduced the serum separation to negligible levels and increase the viscosity. Treated camel's milk yoghurt samples were found to carry an familiar taste and odour to camel's milk yoghurt even at low concentrations. Treatment 3% is recommended for camel's milk yoghurt to stabilize the texture without affecting the flavour of the final product.

Table 3. Sensory properties of camel's milk yoghurt made with modified starch during storage at 5±2°C for three weeks

Parameter	Storage period (week)	Control	1%	2%	3%	4%	5%	Main effects	LSD
Colour and Appearance (9)	Fresh	7.53±0.47^{a}	7.55±0.95^{a}	8.11±0.89^{a}	8.56±1.06^{a}	8.53±1.53^{a}	8.22±1.22^{a}	8.08±0.99^{A}	1.90
	1	6.32±0.68^{c}	7.61±0.39^{abc}	8.33±0.83^{ab}	8.62±0.38^{a}	7.74±1.24^{ab}	7.21±0.29^{bc}	7.63±0.97^{A}	1.27
	2	5.46±0.54^{b}	6.11±1.39^{ab}	7.11±0.89^{ab}	7.54±0.96^{a}	7.23±0.77^{a}	7.11±0.61^{ab}	6.76±1.07^{B}	1.61
	3	4.54±0.46^{b}	5.35±1.15^{ab}	5.66±0.16^{ab}	6.51±0.51^{a}	6.15±0.65^{a}	6.34±1.34^{a}	5.75±0.98^{C}	1.46
	Main effects	5.96±1.24^{c}	6.65±1.34^{bc}	7.30±1.27^{ab}	7.80±1.12^{a}	7.41±1.31^{ab}	7.22±1.08^{ab}	7.06±1.33	1.00
Aroma (9)	Fresh	8.33±1.33^{a}	7.55±0.45^{a}	7.51±1.51^{a}	7.43±0.57^{a}	7.21±0.71^{a}	7.11±0.89^{a}	7.52±0.92^{A}	1.76
	1	7.62±2.12^{a}	7.33±1.33^{a}	7.21±0.29^{a}	6.56±0.56^{a}	6.47±1.47^{a}	6.24±0.74^{a}	6.90±1.17^{A}	2.23
	2	5.42±1.42^{a}	6.13±1.14^{a}	6.25±0.75^{a}	6.11±0.89^{a}	5.53±0.47^{a}	5.51±0.49^{a}	5.82±0.85^{B}	1.64
	3	4.18±0.82^{a}	5.28±0.22^{a}	5.61±1.11^{a}	5.29±0.29^{a}	5.11±0.61^{a}	5.01±1.01^{a}	5.08±0.78^{C}	1.34
	Main effects	6.38±2.15^{a}	6.57±1.23^{a}	6.64±1.17^{a}	6.35±0.96^{a}	6.08±1.15^{a}	5.96±1.08^{a}	6.33±1.32	1.02
Body and texture (9)	Fresh	6.45±0.95^{b}	7.26±0.76^{b}	8.54±0.42^{a}	8.51±0.26^{a}	8.55±0.22^{a}	8.61±0.11^{a}	7.98±0.97^{A}	0.97
	1	5.77±0.23^{b}	6.58±1.08a^{b}	8.11±1.11^{a}	8.59±1.59^{a}	8.55±1.05^{a}	8.56±1.56^{a}	7.69±1.51^{A}	2.12
	2	4.54±1.04^{b}	5.39±0.89^{b}	7.25±1.25^{a}	7.45±0.95^{a}	7.58±0.58^{a}	7.65±1.15^{a}	6.64±1.51^{B}	1.78
	3	3.52±0.48^{b}	4.63±1.13^{b}	6.33±0.83^{a}	6.45±0.95^{a}	6.51±1.01^{a}	6.75±0.75^{a}	5.69±1.43^{C}	1.57
	Main effects	5.07±1.34^{c}	5.96±1.37^{b}	7.55±1.20^{a}	7.75±1.27^{a}	7.79±1.10^{a}	7.90±1.19^{a}	7.01±1.60	1.08
Taste (9)	Fresh	8.22±0.72^{a}	8.16±1.16^{a}	7.56±0.44^{a}	7.51±0.51^{a}	7.24±0.74^{a}	7.11±1.11^{a}	7.63±0.81^{A}	1.47
	1	8.55±1.05^{a}	8.31±1.31^{a}	7.25±0.25^{ab}	7.11±0.61^{ab}	6.53±0.53^{b}	6.21±0.29^{b}	7.32±1.09^{A}	1.38
	2	7.21±0.22^{ab}	7.51±0.01^{a}	7.11±0.11^{ab}	6.58±0.58^{bc}	6.25±0.26^{c}	5.89±0.87^{c}	6.76±0.70^{B}	0.81
	3	5.22±0.22^{a}	6.16±0.17^{a}	6.23±0.73^{a}	6.55±1.55^{a}	5.23±0.27^{a}	5.45±0.95^{a}	5.01±0.87^{C}	1.45
	Main effects	7.30±1.46^{a}	7.53±1.16^{a}	7.04±0.64^{ab}	6.94±0.87^{ab}	6.31±0.86^{b}	6.16±0.97^{b}	6.88±1.11	0.84
Overall Acceptability (9)	Fresh	6.21±0.71^{a}	7.35±0.85^{a}	8.16±1.16^{a}	8.52±1.02^{a}	8.13±2.13^{a}	6.52±1.02^{a}	7.48±1.37^{A}	2.20
	1	5.13±0.63^{c}	6.52±0.52^{ab}	7.18±0.68^{ab}	7.56±0.58^{a}	6.53±0.55^{ab}	6.12±0.62^{bc}	6.51±0.94^{B}	1.05
	2	4.54±0.54^{c}	6.11±0.61^{ab}	6.56±0.57^{ab}	7.22±0.72^{a}	6.35±1.35^{ab}	5.58±0.59^{bc}	6.06±1.08^{B}	1.39
	3	4.17±1.17^{b}	5.48±0.98^{ab}	5.75±0.77^{ab}	6.17±0.67^{a}	6.18±1.18^{a}	4.54±0.56^{ab}	5.38±1.11^{C}	1.63
	Main effects	5.02±1.06^{d}	6.37±0.96^{bc}	6.91±1.15^{ab}	7.36±1.09^{a}	6.79±1.45^{ab}	5.69±0.98^{cd}	6.35±1.34	0.92
Total scores (45)	Fresh	36.74±3.24^{a}	37.77±1.27^{a}	39.28±1.16^{a}	40.13±1.88^{a}	38.76±4.43^{a}	37.47±2.47^{a}	38.35±2.53^{A}	4.75
	1	33.39±2.89^{a}	36.35±3.85^{a}	38.08±2.08^{a}	38.44±2.94^{a}	35.82±4.82^{a}	34.24±2.24^{a}	36.05±3.34^{B}	5.83
	2	27.17±2.67^{c}	31.25±1.25^{b}	34.28±1.78^{ab}	34.90±0.40^{a}	32.94±0.94^{ab}	31.74±2.74^{ab}	32.05±3.03^{C}	3.28
	3	22.63±0.37^{b}	27.10±0.70^{ab}	29.36±3.36^{a}	31.07±4.07^{a}	28.58±2.58^{a}	28.09±4.59^{a}	27.57±3.99^{D}	5.44
	Main effects	29.73±6.44^{c}	33.01±4.92^{b}	35.25±4.47^{ab}	36.13±4.29^{a}	34.02±4.96^{ab}	32.88±4.80^{b}	33.51±5.23	4.06

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($p \leq 0.05$).

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تأثير إضافة النشا المعدل كمثبت على الخواص الفيزوكيميائية والتركيبية ليوغورت لبن النوق

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الهدف من الدراسة تقدير تأثير إضافة تركيزات مختلفة من النشا المعدل (١، ٢، ٣، ٤ و٥%، وزن/ وزن) على الخواص الفيزوكيميائية والتركيبية والحسية ليوغورت لبن النوق أثناء التخزين على ٥ ± ٢°م لمدة ٣ أسابيع، أدت إضافة النشا المعدل إلى انخفاض انفصال الشرش، وزيادة اللزوجة والقدرة على الاحتفاظ بالماء في يوغورت لبن النوق ($P \leq 0.05$) ، بالإضافة إلى ذلك تعزيز القبول الحسي، حيث أدت إضافة النشا المعدل الى التأثير على الحموضة والمواد الصلبة الكلية في يوغورت لبن النوق، القدرة على الاحتفاظ بالماء والقابلية لانفصال الشرش في يوغورت لبن النوق تأثرت بشكل كبير بمعدل الاضافة من النشا المعدل، وقد سجلت أفضل النتائج باستخدام النشا المعدل حتى ٣%، زيادة كمية النشا المعدل المضافة، أدى إلى زيادة قدرتها على الاحتفاظ بالماء وانخفاض القابلية لانفصال الشرش، أدت إضافة النشا المعدل إلى خفض حموضة المعايرة وارتفاع قيم pH في يوغورت لبن النوق مقارنة بعينات المقارنة، إضافة النشا المعدل ليوغورت لبن النوق أدى الى زيادة الجوامد الكلية عن عينات المقارنة، إضافة النشا المعدل أدت إلى زيادة اللزوجة أعلى من عينات المقارنة، وقد أظهرت صور الميكروسكوب الإلكتروني أن النشا المعدل احتل مساحة الفراغ داخل شبكة جسيمات الكازين، اليوغورت المعامل بالنشا المعدل أكثر تنظيم وتوزيع للبروتينات مع هيكل خشن بعض الشيء وكذلك أقل مسامية في شبكة البروتين، فضلاً عن إضافة النشا المعدل ليوغورت لبن النوق أدى الى إندماج ميسيلات الكازين مع بعضها البعض، مما يزيد من تماسك الكازين مقارنة بعينات المقارنة، المعاملات الأكثر من ٣% والتي احتفظت بأعلى معدل للقدرة للاحتفاظ بالماء كانت أعلى تماسك وصلابة في القوام، ويمكن القول إن اضافة النشا المعدل أدت الى تحسين القوام والخصائص الحسية ليوغورت لبن النوق حتى تركيز٣% دون التأثير على القبول العام للمنتج.

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