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PHYSICOCHEMICAL PROPERTIES OF YOGHURT FORTIFIED WITH DIFFERENT ZINC SALTS

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ABSTRACT

Fresh buffalo's milk of 6% fat was heated. Each of three zinc salts (Zinc gluconate, zinc sulphate and zinc acetate) was added to individual milk sample at levels of 30 mg Zn/L milk with the addition to the control treatment. Then, cooled, and inoculcated with 3% mixed culture of *Lactobacillus delbrueckii sub sp. bulgaricus* and *Streptococcus salivarius sub sp thermophilus*. and incubated at 42°C until firm curd was formed at pH 4.6. The resultant yogurt was kept in refrigerator (6±1°C) for 10 days. Results showed a reduction in pH values, lactose content and the wheying off resulting in from the prepared yoghurt which supplemented with zinc salts. Whereas, an opposite trend was noticed for acidy, curd tension. While, yoghurt supplemented with zinc acetate recorded the highest value of acetaldehyde content. Moreover the zinc sulphate gained the highest viscosity till the 7 th day of storage. Concerning the sensory properties, enriching yoghurt with zinc gluconate recorded the highest score in flavor, body & texture.
Keywords: Zinc.fortification. yoghurt.

INTRODUCTION

Yoghurt is an ancient wonderfull food, strongly antibacterial and anti-cancer. A cup or two of yoghurt a day boosts immune functioning by stimulating production of gamma interferon (Wheeler *et al*. 1997), in addition to its super activity of natural killer cells that attack viruses and tumors. A daily cup of yoghurt reduced colds and other upper respiratory infections in human, and cures diarrhea (Pashapour 2006). Full fat yoghurt helps fight bone problems, such as osteoporosis, because of its high availability of calcium content (Heaney *et al.,* 2002). Plain yoghurt with L bulgaricus and S. thermophilus cultures, either live or dead, blocked lung cancers in animals. Yoghurt with live cultures is safe for people of lactose intolerance.

Fermented milk products are widely consumed for their benefits and refreshing effects, that could be due to their popularity which attributed to their nutritional benefits for the consumers (Jensen & Kroger, 2000). Such products already proved to have a positive health image (Jelen *et al*., 2003 and Valli & Traill, 2005).

However, milk product is generally a poor source for trace elements, particularly, zinc (Jayasekar *et al.,* 1992). Also, in this connection, (Jarrstt. 1979) reported that milk is considered to be deficient in zinc. Therefore, consumers need to obtain their sufficient requirements of this trace element from products other than milk.

Zinc is an essential trace element in human nutrition, and its deficiency is world-wide nutritional problem. Regarding the nutritional importance of zinc, the Ontario Ministry of the Environment (2004) reported the minimal risk level of zinc for chronic exposure is 0.3 mg/kg body weight per day. Moreover, the organic nature of zinc gluconate as a source of zinc was proved to be easier absorbed in the digestive system and its absorption rate looks to be higher than the inorganic type.(Rayman,2004). Zinc deficiency is characterized by growth retardation, loss of appetite, and impaired immune function. In more severe cases, zinc deficiency causes hair loss, diarrhea, delayed sexual maturation, impotence, hypogonadism in males, eye and skin lesions (Maret and Sandstead, 2006 and Wang & Busbey, 2005). Clinical zinc deficiency in humans was first described in 1961, when the consumption of diets with low zinc bioavailability due to high phytic acid content which associated with "adolescent nutritional dwarfism" in the Middle East (Prasad, 2004).

Zinc plays a key role in the synthesis and action of insulin (Arthur 1998). Also, researchers have suggested that both zinc and antioxidants delay the progression of age-related macular degeneration (AMD) and vision loss, possibly by preventing cellular damage in the retina (Evans 2006). Individuals with low zinc levels have shown reduced lymphocyte proliferation response to mitogens and other adverse alterations in immunity that can be corrected by zinc supplementation (Wintergerst *et al*., 2007).

It is obviously suggested that dairy prepared products should be fortified with zinc salts. (Uspenskaya 1991) reported that a culture product containing lactobacterin with zinc enrichment had an effective role in the treatment of coeliac disease in children of 1-10 years. Also, (Drago *et al.* 2002) found that lactic acidification and fermentation increased Zn availability in yoghurt fortified with this microelement. (Faten *et al*, 2010) studied and evaluated milk drinks fermented by probiotic bacteria fortified with zinc sulfate or zinc acetate with 10 and 20 mg zinc for 10 days at 5˚C. Moreover, (Amlerova and Cvak 1989) recorded the average zinc content in cheese which was 25-50 mg/kg. Zinc supplementation or food fortification with an adequate zinc compound may be the key to overcome such a worldwide nutritional problem (Salgueiro *et al*., 2002). The fortification was done by adding little amounts of zinc sulfate or zinc acetate (10 or 20 mg zinc element /L) to the prepared yoghurt.

Therefore, the target of this study was to investigate the effect of fortifying yoghurt with different sources of zinc salts (Zinc sulfate, Zinc gluconate, and Zinc acetate) on the physicochemical and sensory properties of zinc-fortified yoghurt.

MATERIALS AND METHODS

Fresh whole buffalo’s milk (15.13% total solid, 4.11% total protein and 6.2% Fat) was obtained from the herd of Mahalet Mossa Station, Kafr el-Shikh governorate,. Milk was standardized to 6 % fat content by mixing the whole and skim milk according to the appropriate calculation.

Mixed culture consisted of *Lactobacillus delbrueckii sub sp. bulgaricus* and *Streptococcus salivarius sub sp thermophilus* were obtained from Chr.

Hansen's Lab A/S Copenhagen, Denmark. : Zinc gluconate, Zinc sulphate and Zinc acetate (food grade) were obtained from Chemical Industries Developments (CID) Company for drugs.

Acetaldehyde was obtained from Cambrian Chemicals Bsddington Farm, Road Croydon CRO 4XB.

Fresh buffalo's milk of 6% fat was heated to 80°C for 20 min, and cooled to 42°C. Each of the three zinc salts (Zinc gluconate, zinc sulphate and zinc acetate) was added to individual milk sample at levels of 30 mg Zn/L milk, with the addition of control forming four treatments. and inoculcated with 3% mixed culture of *Lactobacillus delbrueckii sub sp. bulgaricus* and *Streptococcus salivarius sub sp thermophilus* (1:1). Finally, each of the various treatments was distributed into 120 ml plastic cups and incubated at 42°C till firm curd was formed at pH 4.6. The prepared yogurt was kept in refrigerator (6±1°C) for 10 days. Samples of yoghurt were analyzed when fresh and during 3, 7 & 10 days storage. Three replicates of each treatment were conducted.

Milk and yoghurt samples were analyzed for the total solids, total protein and fat, and titrtable acidity, according to methods described by A.O.A.C (2000). The pH values were measured using a laboratory pH meter type HANNA instrumenting (8417) pH meter. Lactose content was calorimetrically determined according to (Bernett and Abd El–Tawab 1957), using spectrophotometer at 490 nm wavelength type Shimadzu UV 240. Acetaldehyde content (ppm) was estimated as described by (Lees and Jago 1969) using Conway micro-diffusion semi-carbazide method. Acetaldehyde with semi carbazide was used to form semi carbazone, which has the absorption peak at 224nm. The analysis procedure was as follows:- One ml of semi-carbazide solution (6.7 mM) was pipetted in the inner wall of Conway micro-diffusion cell. Three ml of yoghurt were rapidly pipetted in the outer compartment and the cell was covered, sealed tightly by plaster and incubated at 30°C for 90 min. The solution in the inner wall was transferred to 10 ml volumetric flask and adjusted to volume with distilled water. The absorption was measured at 224 nm wave length using the spectrophotometer type Shimadzu UV 240. The concentration of acetaldehyde was calculated using the prepared standard curve of the acetaldehyde solution.

The apparent viscosity of yoghurt was determined using Brookfield DV- E viscometer, using spindle 0.5 at 50 rpm in 200 ml of yoghurt sample, the temperature was maintained at 25˚C and viscosity value was expressed in centipoises (cp).

Fifteen trained panelists from the research staff of the Department of Dairy Sections of Animal Production Research Institute, Agricultural research center judged the examined yoghurt. Yoghurt samples evaluated fresh and during 3, 7 and 10 day storage using score card for flavor (50 points), body & texture (40 points) and color (10 point).

Data were statistically analyzed using General Linear Model procedure of SAS® Program (1996) according to the following model:

$Y_{ijk...} = \mu + T_i + S_j + TS_{ij} + e_{ijk,}$

Where Y_{ijk} = The observation, µ = General mean, T_i = Fixed effect of i^{th} zinc supplementation, i = 1, 2, ….4, S_j = Fixed effect of j^{th} storage period (j= 0, 3, 7 and 10 days), TS_{ij} = the fixed effect of interaction between zinc supplementation and storage period, and e_{ijk} = Error of the model. Significance of the differences in results tested by Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The pH values for yoghurt fortified with or without different zinc salts are substantially decreased with increasing incubation time (Table 1). After 30 minute of incubation, yoghurt fortified with zinc gluconate recorded the lowest pH value, followed by zinc acetate and zinc sulphate, compared with yoghurt without zinc supplementation (control). After 150 min of incubation, all zinc fortified treatments were almost at pH 4.6, whereas their control recorded 4.6 pH after 180 minutes. These obtained results revealed that supplementation with zinc salts at a level of 30 mg /L buffalo's milk caused further decrease in pH values as a result of the activated response on the microorganism of yoghurt (Jarrstt, 1979 and Momeilovic & Kello, 1979). Along the same line, (Koladkin *et al*. 1974) reported that the addition of Zn, Fe and Cu sulphate to milk increased the acidity due to more intensive growth of lactic streptococci and total number of micro flora during incubation and during storage.

Table (1): Effect of yoghurt fortification of with different zinc salts (30 mg Zn/L Buffalo's milk) on the pH values during incubation intervals.

Treatments	Incubation time (minutes)						
	0	**30**	**60**	**90**	**120**	**150**	**180**
Control	6.62	6.40	6.27	5.83	5.75	5.38	4.61
Zinc sulphate	6.61	6.25	5.85	5.49	4.82	4.57	
Zinc gluconate	6.59	6.03	5.72	5.30	4.92	4.60	
Zinc acetate	6.60	6.19	5.65	5.13	4.83	4.67	

Total fat content of yoghurt was not significantly affected by zinc supplementation (un tabulated data). Yoghurt fortification with zinc sulphate, zinc gluconate or zinc acetate with 30 mg Zn/L milk were nearly similar to their control in total fat content throughout the refrigerated storage periods of 10-day . The values ranged between 6 - 6.2%. This result is in agreement with those of (Ezzat abd El-Fattah *et al*., 2008) on previous study in the effect of mineral content of milk and milk products.

Total solids and total protein contents of yoghurt were insignificantly affected by zinc supplementation (Table 2). Yoghurt fortified with different zinc salts (zinc sulphate or zinc glluconate or zinc acetate) at ratio of 30 mg Zn/L milk and their control didn't show significant differences in their total solids of fresh, and throughout the prolonged refrigeration storage period of 10 days as they tended to exert slight increase as shown in Table (2). Such increase may be attributed to the natural evaporation as reported by (Salem *et al.* (1997) and Al-assar *et al*. (2005), when fermented milk fortified with zinc salts.

Lactose content of yoghurt was significantly (P<0.05) affected by zinc supplementation, refrigerated storage periods and their interaction (Table 2). Results indicated that lactose content in fresh fortified yoghurt with zinc salts induced reduction in lactose content , compared with their control and throughout refrigerated storage periods. This might be attributed to the acceleration effect of zinc salts supplementation on yoghurt bacterial growth. Such obtained results were in agreement with those of (Degheide, 1998) and (Ezzat abd El-Fattah *et al* ,2008).

Table (2): Total solids, total protein and lactose content (%) of yoghurt fortified with different zinc salts (30 mg Zn/L Buffalo's milk) during refrigerated storage 6±1˚C.

Storage periods (days)	Control	Zinc sulphate	Zinc gluconate	Zinc Acetate	±SE	Average
			Total Solids (%)			
Fresh	15.13	15.21	15.39	15.29	0.26	15.25
3	15.29	15.39	15.61	15.41	0.26	15.43
7	15.38	15.63	15.70	15.55	0.26	15.56
10	15.43	15.71	15.77	15.70	0.26	15.65
Average	15.31	15.48	15.62	15.49	0.14	
			Protein content (%)			
Fresh	4.11	3.97	4.05	4.08	0.18	4.05
3	4.26	4.16	4.21	4.22	0.18	4.21
7	4.37	4.29	4.45	4.35	0.18	4.36
10	4.43	4.41	4.54	4.49	0.18	4.47
Average	4.29	4.21	4.31	4.29	0.09	
			Lactose content (%)			
Fresh	4.2^{a}	4.0^{ab}	4.1^{a}	3.9^{c}	0.11	4.05^{A}
3	3.8^{c}	3.5^{d}	3.5^{d}	3.3^{ef}	0.11	3.52^{B}
7	3.5^{d}	3.3^{e}	3.3^{e}	3.1^{fg}	0.11	3.30^{C}
10	3.2^{f}	2.9^{g}	3.1^{fg}	3.0^{g}	0.11	3.05^{D}
Average	3.67^{A}	3.43^{BC}	3.50^{B}	3.33^{C}	0.06	

^{A,B,C} Mean with different superscripts in the same row or column within item differ significantly (P<0.05).

^{a,b,c} Mean with different superscripts in the same rows within item differ significantly (P<0.05).

Acidity, pH values and acetaldehyde content of yoghurt were significantly (P<0.05 or 0.01) affected by zinc supplementation, refrigerate storage periods and their interaction (Table 3). The acidity of yoghurt increased significantly (P<0.05) by the addition of zinc salts in fresh or during refrigerated storage periods, compared with their control. The highest rate of acid development was recorded in the fortified yoghurt with zinc acetate, and no significant different was observed between zinc acetate and zinc sulphate salts after 10 days of storage (Table 3). Such increase in acidity could be due to the acidic effect of the added salts, or to the more lactic acid bacterial growth which subsequently developing acidity throughout 7 day of storage, with a lactose reduction and a decrease in the pH values of the prepared yoghurt.

It should be noticed that changes in acidity is reflected on the reduction of lactose content. These results are in agreement with those reported by Badawi and El-Sonbaty (1997), Abd Rabou *et al.* (1999), Kebary and Hussein (1999), Alroubaiya (2004) and Ezzat abd El-Fattah *et al*. (2008). While pH values behaved in an opposite trend of the acidity

Data in Table (3) indicated that acetaldehyde content of yoghurt samples recorded the highest values with the addition of zinc acetate, as compared with their control, and throughout storage periods of 10 days. In addition, values of acetaldehyde significantly decreased during refrigerated storage due to the its conversion to other organic compounds (Lees & Jago, 1976). In this respect Salama and Hassan (1994) reported that the decrease in acetaldehyde content of yoghurt during storage might be due to the ability of numerous lactic organisms to convert acetaldehyde to ethanol or oxidize it to acetic acid.

Table (3): Acidity (%), pH values and acetaldehyde content µg/100ml of yoghurt fortified with different zinc salts (30 mg Zn/L Buffalo's milk) during refrigerated storage 6±1˚C.

Storage periods (days)	Control	Zinc sulphate	Zinc gluconate	Zinc acetate	±SE	Average
			Acidity (%)			
Fresh	0.75^{g}	0.83^{ef}	0.80^{efg}	0.92^{d}	0.018	0.825^{D}
3	0.78^{fg}	0.85^{e}	0.92^{d}	0.99^{c}	0.018	0.885^{C}
7	0.81^{efg}	0.91^{d}	1.02^{c}	1.09^{b}	0.018	0.957^{B}
10	0.85^{e}	1.19^{a}	1.09^{b}	1.21^{a}	0.018	1.085^{A}
Average	0.797^{C}	0.945^{B}	0.957^{B}	1.052^{A}	0.009	
			pH values			
Fresh	4.46^{a}	4.31^{b}	4.37^{ab}	4.15^{c}	0.034	4.32^{A}
3	3.78^{f}	3.41^{h}	3.97^{d}	3.95^{d}	0.034	3.78^{B}
7	3.57^{g}	3.18^{i}	3.89^{de}	3.80^{ef}	0.034	3.61^{C}
10	3.41^{h}	3.08^{j}	3.64^{g}	3.65^{g}	0.034	3.45^{D}
Average	3.81^{C}	3.49^{D}	3.97^{A}	3.89^{B}	0.017	
			Acetaldehyde content µg/100ml			
Fresh	173^{d}	163^{e}	159^{e}	255^{a}	2.59	187.5^{A}
3	159^{e}	142^{f}	133^{g}	215^{b}	2.59	162.3^{B}
7	142^{f}	125^{hi}	119^{ij}	183^{c}	2.59	142.3^{C}
10	131^{gh}	117^{j}	103^{k}	171^{d}	2.59	130.5^{D}
Average	151.3^{B}	136.7^{C}	128.5^{D}	206.0^{A}	1.29	

^{A,B,C} Mean with different superscripts in the same row or column within item differ significantly (P<0.05).

^{a,b,c} Mean with different superscripts in the same rows within item differ significantly (P<0.05).

Syneresis and curd tension of yoghurt were significantly (P<0.05) affected by zinc fortified, storage periods and their interaction, except for curd tension which was insignificantly affected by storage periods (Table 4). Results in Table (4) clarified that using any of the applied zinc salts (zinc sulphate, zinc gluconate or zinc acetate) decreased the wheying off (the amount of excreted whey) in fresh and throughout storage periods of the prepared yoghurt. These results revealed that the effect of zinc salts during manufacturing yoghurt might enhance the water binding capacity of yoghurt coagulum, which in turn influencing the rate of syneresis. Similar results were reported by Mehanna and Hefnawy (1990), Mansoour *et al.* (1994) and kalafalla & Roushdy (1996).

Curd tension results revealed an opposite trend of syneresis values, where yoghurt was affected by fortification with zinc salts with significant increase in its curd tension as compared with their control either in fresh or during storage periods (Table 4). The highest values were recorded in zinc sulphat, followed by zinc gluconate then zinc acetate.

Table (4): Synercis (ml) and curd tension (gm) of yoghurt fortified with different zinc salts (30 mg Zn/L Buffalo's milk) during refrigerated storage 6±1˚C.

Storage periods (days)	Control	Zinc sulphate	Zinc gluconate	Zinc acetate	±SE	Average
			Synercis (ml)			
Fresh	28^{defg}	25^{efg}	22^{g}	23^{fg}	2.11	24.50^{C}
3	33^{bcd}	31^{bcde}	29^{cde}	28^{efg}	2.11	30.25^{B}
7	38^{ab}	34^{abcd}	34^{abcd}	35^{abcd}	2.11	35.25^{A}
10	41^{a}	36^{abc}	36^{abc}	38^{ab}	2.11	37.75^{A}
Average	35.0^{A}	31.5^{B}	30.2^{B}	31.0^{B}	1.05	
			Curd tension (gm)			
Fresh	16.64^{c}	20.28^{a}	18.88^{b}	18.84^{b}	0.165	18.66^{A}
3	16.93^{c}	19.95^{a}	18.95^{b}	18.91^{b}	0.165	18.68^{A}
7	16.99^{c}	19.99^{a}	19.03^{b}	19.03^{b}	0.165	18.83^{A}
10	17.07^{c}	20.03^{a}	19.23^{b}	19.11^{b}	0.165	18.86^{A}
Average	16.91^{C}	20.06^{A}	19.09^{B}	18.90^{B}	0.082	

[A,B,C] Mean with different superscripts in the same row or column within item differ significantly (P<0.05).

[a,b,c] Mean with different superscripts in the same rows within item differ significantly (P<0.05).

Values of viscosity were almost triple higher (P<0.01) in yoghurt fortified with zinc sulphate followed by yoghurt fortified with zinc gluconate, then yoghurt fortified with zinc acetate as compared with their control (Table 5). These results might be attributed to different nature of zinc salts in their component of mineral and organic structure. The highest viscosity values in yoghurt fortified with zinc salts might be due to the interaction between protein and zinc salts. It could be noticed that the control samples recorded the lowest viscosity value when fresh. Whereas, during storage periods viscosity of yoghurt samples fortified with zinc salts showed significant (P<0.001) reduction till 10-day storage, whereas the control yoghurt behaved in an opposite trend. These results are in agreement with those of (Faten *et al* ,2010), when thy studied and evaluated milk drinks fermented by probiotic bacteria fortified with zinc sulfate or zinc acetate with 10 and 20 mg zinc for 10 days at 5˚C.

Table (5): Viscosity of yoghurt fortified with different zinc salts (30 mg Zn/L Buffalo's milk) during refrigerated storage 6±1˚C.

Storage periods (days)	Control	Zinc sulphate	Zinc gluconate	Zinc acetate	±SE	Average
Fresh	408^{j}	1232^{a}	640^{d}	552^{f}	5.08	708.00^{A}
3	493^{h}	953^{b}	462^{i}	539^{f}	5.08	611.75^{B}
7	613^{e}	642^{d}	272^{l}	521^{g}	5.08	512.00^{C}
10	784^{c}	320^{k}	176^{m}	513^{g}	5.08	448.25^{D}
Average	574.5^{B}	786.75^{A}	387.50^{D}	531.25^{C}	2.54	

[A,B,C] Mean with different superscripts in the same row or column within item differ significantly (P<0.05).

[a,b,c] Mean with different superscripts in the same rows within item differ significantly (P<0.05).

Sensory properties of yoghurt were significantly (P<0.05) affected by zinc supplementation or storage periods (Table 6). Yoghurt supplemented with zinc gluconate have significant increased in its sensory scores especially in flavor and body texture, as compared with their control. The other treatments iwhen fresh and during refrigerated storage periods. Meanwhile yoghurt fortified with zinc acetate received slightly lower scores than yoghurt fortified with zinc sulphate and the control in fresh and during storage periods. Similar results were reported by Nelson and Trout (1981) and Ezzat *et al* .(2008). No detectable changes were observed in color of the fortified samples which gained 9 out of 10 point same as control scores.

Table (6): Sensory properties of yoghurt fortified with different zinc salts (30 mg Zn/L Buffalo's milk) during refrigerated storage 6±1˚C.

Storage periods (days)	Treatments	Flavor (50)	Body & texture (40)	Color (10)	Total (100)
Fresh	**Control**	٤٧	٣٩	٩	٩٥
	Zinc sulphate	42	36	9	87
	Zinc gluconate	٤٨	٤٠	9	٩٧
	Zinc acetate	٤٠	٣٥	٩	٨٤
3	**Control**	٤٦	٣٩	٩	94
	Zinc sulphate	٤٠	٣٦	٩	٨٥
	Zinc gluconate	٤٧	٣٩	٩	٩٥
	Zinc acetate	٣٨	٣٥	٩	٨٢
7	**Control**	٤٤	٣٩	٩	92
	Zinc sulphate	٣٩	٣٦	٩	٨٤
	Zinc gluconate	٤٤	٣٩	٩	٩٢
	Zinc acetate	٣٥	٣٥	٩	٧٩
10	**Control**	٤٢	٣٨	٩	٨٩
	Zinc sulphate	٣٧	٣٥	٩	٨١
	Zinc gluconate	٤٢	٣٨	٩	٨٩
	Zinc acetate	٣٥	٣٣	٩	٧٧
Standard error		±4.60	±1.98	±0.58	±5.14
Storage periods		*	*	NS	*
Zinc supplementations		*	*	NS	*
Interaction		NS	NS	NS	NS

**** P<0.01, * P<0.05 and NS= No significant.**

It could be concluded that enriching yoghurt with zinc salt decreased the time for incubation period to 150 minutes. In addition all yoghurt treatments fortified with zinc salts contained more acetaldehyde and less wheying off when fresh and throughout storage periods. Zinc gluconate gained the highest sensory score in fresh, when compared with the control as compared with zinc sulphate and zinc acetate.

So, it is more likely that zinc gluconate could be the best zinc source in this study for yoghurt fortification. This due to its effect in producing yoghurt of high nutritive value with favorable physicochemical and sensory properties.

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الصفات الطبيعية والكيماوية للزبادى المدعم بأنواع مختلفة من املاح الزنك

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فى هذا البحث تم استخدام انواع مختلفة من املاح الزنك (جلوكونات الزنك – كبريتات الزنك – خلات الزنك) لتدعيم اللبن. وتم اضافة املاح الزنك بنسبة ٣٠ ملليجرام زنك/ لتر لبن وذلك بجانب معاملة المقارنة.

تم تصنيع زبادى من اللبن المدعم بالانواع المختلفة من املاح الزنك وتخزينة لمدة ١٠ ايام بالثلاجة على درجة حرارة ٦ ± ١ ° م . وتم خلال فترة التخزين اجراء التحاليل الكيماوية والريولوجية وتقييم الصفات الحسية.

واظهرت نتائج التحليل الكيماوى انخفاض فى قيمة ال pH وكذلك محتوى اللاكتوز والتشريش فى العينات المدعمة باملاح الزنك واظهرت النتائج ازتفاع نسبة الحموضة وتماسك قوة الخثرة.

اعطت عينات الزبادى المدعم بخلات الزنك اعلى نتائج فى محتوى الاسيتالدهيد . وفى العينات المدعمة بكبريتات الزنك اعطت اعلى النتائج فى اللزوجة حتى اليوم السابع من التخزين.

واظهرت نتائج التحكيم الحسى والريولوجى ان جلوكونات الزنك اعطت اعلى درجات التحكيم فى النكهه وتماسك قوة الخثرة.

قام بتحكيم البحث

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