Elimination of Yoghurt's Wheying off Defect by A Natural Stabilizer Extracted from Taro Tubers

M. A. Mahmoud [*], A. A. Elhadidi, H. M. Ali, S. A. Soliman

Dairy Department, Faculty of Agriculture, Al Azhar University, Cairo, Egypt

*Corresponding author E-mail: halimshafe.5@azahar.edue.eg (M. Mahmoud)

ABSTRACT

The study aimed to find out to what extent the mucilage extracted from taro tubers can succeed as a natural stabilizer in stabilizing the texture of the yoghurt and eliminating the common wheying off defect that occurs in such product. To achieve this purpose, taro mucilage was extracted, dried and added to yoghurt milk, buffalo's milk fat standardized to 3.5 %, at level of nil (control), 0.1, 0.3 or 0.5 %. The obtained results indicated that, yoghurt stabilization with dried taro mucilage extract (DTME) was associated with increase in total solids content, pH value and viscosity. The water holding capacity (WHC), all parameters of texture profile analysis (TPA) namely, hardness, cohesiveness, springiness, gumminess, and chewiness as well as sensory attributes including, appearance, body & texture, flavor and total scores were improved also by DTME adding providing that the level did not exceeded 0.3 %. Whilst both of protein, fat and ash contents, as well as lactic acid bacteria population were not affected, while titratable acid % decreased by DTME adding until 0.5%. Syneresis was reduced when the level of DTME was heightened up to 0.3%. During cold storage period for 15 days, all foregoing parameters were gradually raised except of pH value, WHC and scores of all sensory criteria, those were proportionally decreased as yoghurt cold stored. The foregoing results led to conclude that the DTME could successfully eliminate the wheying off defect when added to yoghurt at 0.3 %.

Keywords: Lactic Acid Bacteria, Water Holding Capacity, Texture Profile.

INTRODUCTION

Yoghurt has more nutritional benefits than milk as it is nutritionally rich in protein, calcium, riboflavin, vitamin B_6 and vitamin B_{12} (Ashraf and Shah, 2011). It also helps in the digestion process, boost immunity, ease diarrhea and protect against cancer (McFarland, 2015). The health benefits of fermented food products were classified t into two groups, which are nutritional function and physiological function (Bell *et al.*, 2017). Nutritional function is supplying sufficient nutrients while physiological function concerns on the prophylactic and therapeutic benefits (Marco *et al.*, 2017).

Texture of Yoghurt is as important as its taste and flavor in terms of consumer preferences (Gonçalvez *et al.*, 2005), which defines the acceptance of the product and is related to viscosity. Under natural conditions, Yoghurt has a poor texture, which leads to syneresis or draining, which is manifested by the expulsion of serum towards the outside of the gel. This phenomenon has a negative influence on the physical and sensory properties of Yoghurt and is a factor in rejection by consumers (Cardenas *et al.*, 2013). Also, the properties of the milk used in Yoghurt production, production and storage conditions or transportation to far sales points can lead to textural defects (Trachoo, 2002). Also, incubation, storage and processing conditions influence these changes. The viscosity of Yoghurt is affected by homogeneity, pH, curing parameters (milk or firm yoghurt) and heat treatment. The synergy defect can be reduced and treated by adding stabilizers which interact with the casein network (Hematyar *et al.*, 2012).

Defined stabilizers as complex carbohydrates except for casein and gelatin, which are proteins. Hydrophilic colloids are generally used due to their hydrophilic properties such as water retention, emulsion stability, and tissue modifying effects. In general, the viscosity increases due to the hydrogen bonds between the water molecules and the hydroxyl groups in the gums. Thus, water is retained in the structure and a stable structure is formed (Li and Nie, 2016).

Taro, *Colocasia esculenta*, is a plant of the Araceae family that is widely cultivated in the tropical areas of the world for its leaves and underground tubers (corms and cormels). It is found in South East Asia, the Pacific Islands, the Mediterranean, Africa and in the North America (Jane *et al.*, 1992). The taro mucilage displays unique rheological properties with great potential as a thickener and food stabilizer (Njintang *et al.*, 2014).

For that in view, the aim of this study was to find out to what extent the mucilage extracted from taro tubers can succeed as a natural stabilizer in stabilizing the texture of the yoghurt and eliminating the common wheying off defect that occurs in such product.

MATERIALS AND METHODS

Materials

Milk

Fresh whole buffalo's milk 15.53 % total solids, 6.5% fat, 4.48 % lactose, 3.85 % protein, 0.18 % titratable acidity and pH value 6.65 was obtained from the herd of Faculty of Agriculture, Al-Azhar University, Mostorod, Great Cairo, Egypt.

Bacterial starter culture

Thermophilic Yoghurt Culture YC-X11was obtained from Chr. Hansen. It is designed to form a mild tasting product and is suitable for cup-set, stirred and drinking Yoghurts. The bacterial strains present were *Lactobacillius delbrueckii subsp. bulgaricus* and *Streptococcus thermophiles* according to manufacturing instructions.

Taro tubers

Taro tubers were obtained from local market at Cairo, Egypt.

Experimental procedures

Taro mucilage extraction

The methodology of Yeh *et al.* (2009) was partially adapted with some modifications to obtain a readily feasible and repeatable technique with less chemical residue generation and lower financial costs as follow: Taro tubers, after peeling and chopping, were soaked in three volumes of distilled water. After crushing in an industrial blender at maximum speed for 2 min, the mixture was filtered by polyester cloth. The residue from the filtrate was mixed again with three volumes of distilled water, homogenized and filtered again. Filtrates were collected and centrifuged at 10,000 g at 4 °C for 20 min. The resulting supernatant was used to isolate the gum. Three volumes of 99.5% ethyl alcohol were added to the supernatant to precipitate the gum. Then, the mixture was re-centrifuged at 10,000 g for 10 min. Then, the precipitate was dried in a 40 °C in vacuum oven for 24 h. The resultant material was soaked with pestle mortar, homogenized, and stored.

Preparation of Yoghurt

Buffalo's milk was firstly fat standardized to 3.5% and divided into four parts, those were separately stabilized with nil (the control), 0.1, 0.3 or 0.5% dried taro mucilage extract (DTME). Then, milk was converted into yoghurt according to the protocol proposed by Tamime and Robinson (1999). Where, every portion was heat treated at 85°C for 5 min, cooled to 42 ± 1 °C, at which was inoculated with 2% freshly prepared yoghurt bacterial starter culture and incubated at the same temperature until complete coagulation was occurred (within 3 h) as in Hassan *et al*. (2010). Three replicated for every treatment were carried out.

Analytical Methods

The chemical composition was analyzed as in AOAC (2012). Yoghurt fat content and titratable acidity percentage were determined according to Ling (1963).

The pH value was measured according to BSI (1994) using a Swiss Gallenkamp stick pH meter with glass electrode.

Syneresis was determined as described by Tamime *et al.* (1996). Water holding capacity (WHC) was measured as in Wu *et al.* (2000). Viscosity was determined as in Toledo (1980) using Swiss made viscometer Drug type TV aunevitesse. Readings (cP) were taken after aging using spindle at 4.0±2°C.

The Texture Profile Analysis (TPA) of yoghurt samples was performed using multi test 1-d texture analyzer, (mecmes in limited, Slinfold, West Sussex, UK). Experiments were carried out by a compression test that generated a plot of force (N) versus time (sec). Samples were double compressed at a compression speed of 2 cm/min. The analysis was carried out at room temperature. Hardness (N), springiness (mm), chewiness (N*mm), gumminess (N) and cohesiveness were evaluated as described by El-Kholy, *et al*. (2019).

Lactic Acid Bacteria were counted using MRS agar medium according to the methods described in the International Standard FIL/IDF 117A (1988). Coliform bacterial counts were enumerated using Violet Red Bile Agar (VRBA) followed by incubation for 1-2 days at 37ºC according to American Public Health Association (APHA) (1992). Molds and yeasts counts were determined using the pour plate method by using Malt Extract Agar (MEA) followed by incubation for 3-5 days at 25ºC according to American Public Health Association (APHA) (1992).

Yoghurt samples were organoleptically evaluated by some panelists from the staff members of the Dairy department, Faculty of Agriculture, Al-Azhar University, Egypt. They evaluated each yoghurt sample and used a quality rating score card for evaluation of appearance (10 points), body and texture (60 points) and flavor (30 points) as described by Hassan *et al*. (1999).

Analysis of variance was computed using the General Linear Model procedure of statistical analysis system (IBM SPSS STATISTICS 20). Variable means for treatments indicating significant differences in the ANOVA were compared according to SAS (1996).

RESULTS AND DISCUSSIONS

Chemical composition of taro mucilage

The present data in Table (1) show the chemical composition of dried taro mucilage extract (DTME) which is used for Yoghurt. As shown, the major component of dried taro mucilage extract was 92.81% total solids (TS), 76.05 % carbohydrates, 0.6% Fat, 2.25% crude fiber, 10.98% protein and 2.93% ash.

Chemical properties of yoghurt stabilized by taro mucilage

Concerning the gross chemical composition of DTME-containing yoghurt samples, the obtained data in Table (2) showed that total solids (TS) contents increased as the fortification level with DTME increased. This may be due to the relatively high total solid content of the added DTME. These results are in agreement with those reported by **Sameen *et al.* (2016).** Moreover, TS content increased significantly as the cold storage period (CSP) prolonged. Nevertheless, neither DTME level nor CSP of yoghurts led to any significant variation in both of their protein, fat or ash contents.

The ascending rate of yoghurt titratable acidity % lowered as DTME level raised. Control yoghurt showed the maximum change in acidity during CSP and the minimum acidity alteration was observed in those containing 0.3 % DTME or more in comparison with those of 0.1% DTME. DTME may cause some reduction in the water activity leading to exhibit such resistance against acidity development during cold storage of yoghurt. Similar observations were reported by Khalifa *et al*. (2011), Andic *et al*. (2013) and Anwer *et al*. (2013). On the contrary, DTME yoghurt pH value was relatively higher.It decreased gradually in all treatments during CSP either in control sample or in DTME-treated samples along 15 days. During storage, decrease in pH was mainly due to the conversion of lactose into lactic acid. The reduction rate in pH value in the present study is in accordance with Hussein *et al.* (2011).

Physical properties of yoghurt stabilized by taro mucilage

Viscosity, syneresis and water holding capacity (WHC) of yoghurt were affected significantly either by DTME adding or CSP (Table, 3). Viscosity of all samples was increased as the DTME level raised on along CSP. Iseleton and Karagul-Yuceer (2006) and Park (2007) explained that yoghurt viscosity increasing during CSP is due to protein rearrangement and protein-protein interaction, temperature and pH value. The results were found to be in accordance with Hussein, *et al.* (2011), Nima *et al*. (2012) and Srisuvor *et al.* (2013).

The stabilization of yoghurt with DTME up to 0.3% was associated with strengthening the WHC and hence lowering the matrix syneresis. The DTME level of 0.5% exhibited opposite trending in both criteria. Nevertheless, a gradual reduction in the WHC and increase in syneresis were correlated to the CSP prolonging. Vliet (1993) attributed this phenomenon to the interaction between casein aggregates and polysaccharides that leads to weaker casein micelles and this interaction was developed when the lactose is converted into lactic acid. The results agreed with those of Hussein *et al.* (2011), Chye *et al.* (2012) and Sakandar *et al*. (2014) who also found that the syneresis of yoghurt increases with storage period.

Textural profile analysis of yoghurt stabilized by taro mucilage

The changes in the texture profile parameters namely, hardness, cohesiveness, gumminess, springiness and chewiness of yoghurt stabilized with different levels of DTME along CSP are shown in Table (4). It could be noticed that, without any exception, all these parameters were gradually heightened in yoghurt whether as the DTME increased up to 0.3% or as the CSP was expressed.

Microbiological situation of yoghurt stabilized by taro mucilage

The microbiological situation of yoghurt as a function of stabilization level with DTME or CSP is given in Table (5).

Regarding the log count of lactic acid bacteria (LAB) of yoghurt, it could be observed that both of the increased stabilization level with DTME and prolonged CSP were proportionally related to LAB population growth. Ammar *et al*., (2009) reported that taro is rich in starch and mucilage, which facilitates the growth of LAB. Abodjo *et al*. (2010), Kim *et al*. (2011) and Pérez *et al*., (2021) declared that, increasing the concentration of DTME in yoghurt provides more starch and mucilage with increased counts of LAB. Lactic acid bacteria can also produce enzymes that could hydrolyze starch into reducing sugars, which can be further metabolized into lactic acids, also may be due to continued metabolic activity for the consumption of lactose and other sugars produced in the biochemical process of lactic acid synthesis.

Moreover, it is worthy to mention that, due to the good sanitation precaution adapted during the manufacture of experimental yoghurt samples, neither coliform bacteria nor molds & yeasts were detected in all samples whether when fresh or along CSP. These results are in accordance with the Egyptian Standard Specifications (8042/2016).

Organoleptic quality

The judging scores displaying in Table (6) indicate that, undoubtedly, the yoghurt stabilized with 0.3% DTME gained the highest acceptability degree whether for appearance, body & texture or flavor followed by that of 0.1% DTME and rather of 0.5% DTME. While the control yoghurt came in the last order especially in body & texture criterion. These results agree with those of Hussein *et al.* (2011).

CONCLUSION

The foregoing results led to conclude that, the dried taro mucilage extract could successfully eliminate the wheying off defect when added to yoghurt milk at the level of 0.3 %.

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Table 1: Chemical composition of dried taro mucilage extract

Total solids %	Carbohydrates %	Fat %	Fiber %	Protein %(Total nitrogen X 6.25)	Ash %
92.81	76.05	0.60	2.25	10.98	2.93

Table 2: Chemical properties of yoghurt stabilized with different levels of dried taro mucilage extract (DTME)

Property	Cold storage period (day)	Yoghurt stabilization level with DTME			
		Nil (control)	0.1 %	0.3 %	0.5 %
Total Solids (%)	Fresh	14.43^{Cc}	14.52^{Cbc}	14.71^{Aab}	14.89^{Da}
	3	14.90^{Bb}	14.68^{BCb}	14.74^{Aab}	15.13^{Ca}
	7	15.40^{Aa}	14.93^{Bb}	14.84^{Ab}	15.41^{Ba}
	15	15.62^{Aa}	15.27^{Ab}	14.98^{Ab}	15.85^{Aa}
Protein % (Total nitrogen X 6.38)	Fresh	4.74^{Aa}	4.75^{Aa}	4.77^{Aa}	4.80^{Aa}
	3	4.89^{Aa}	4.80^{Aa}	4.78^{Aa}	4.87^{Aa}
	7	5.06^{Aa}	4.88^{Aa}	4.82^{Aa}	4.96^{Aa}
	15	5.13^{Aa}	4.99^{Aa}	4.86^{Aa}	5.10^{Aa}
Fat %	Fresh	3.36^{Ba}	3.37^{Aa}	3.37^{Aa}	3.37^{Ba}
	3	3.47^{Aba}	3.40^{Aa}	3.38^{Aa}	3.42^{Ba}
	7	3.59^{Aa}	3.46^{Aa}	3.40^{Aa}	3.48^{ABa}
	15	3.64^{Aa}	3.54^{Aa}	3.43^{Aa}	3.59^{Aa}
Ash %	Fresh	0.79^{Aa}	0.79^{Aa}	0.80^{Aa}	0.80^{Aa}
	3	0.82^{Aa}	0.80^{Aa}	0.80^{Aa}	0.82^{Aa}
	7	0.84^{Aa}	0.82^{Aa}	0.81^{Aa}	0.83^{Aa}
	15	0.86^{Aa}	0.83^{Aa}	0.81^{Aa}	0.86^{Aa}
Titratable acidity %	Fresh	0.92^{Ca}	0.89^{Ca}	0.88^{Ba}	0.89^{Ba}
	3	0.97^{Ca}	0.93^{BCa}	0.91^{Aba}	0.94^{ABa}
	7	1.05^{Ba}	0.99^{ABa}	0.94^{ABa}	0.99^{ABa}
	15	1.19^{Aa}	1.06^{Ab}	0.99^{Ab}	1.08^{Aba}
pH value	Fresh	4.55^{Aa}	4.57^{Aa}	4.59^{Aa}	4.57^{Aa}
	3	4.48^{Ab}	4.52^{ABab}	4.56^{ABa}	4.51^{ABab}
	7	4.39^{Ac}	4.46^{Bab}	4.50^{Ba}	4.44^{BCab}
	15	4.15^{Ad}	4.37^{Ca}	4.42^{Ca}	4.36^{Ca}

Means with different capital letters within each column are significant at 5 % level.
Means with different small letters within each row are significant at 5 % level.

Table 3: Chemical properties of yoghurt stabilized with different levels of dried taro mucilage extract (DTME)

Property	Cold storage period (day)	Yoghurt stabilization level with DTME			
		Nil (control)	0.1 %	0.3 %	0.5 %
Viscosity(cP)	Fresh	8019^{Dd}	8260^{Dc}	8441^{Db}	8771Da
	3	8227^{Cd}	8490^{Cc}	8564^{Cb}	9187^{Ca}
	7	8486^{Bd}	8625^{Bc}	8813^{Bb}	9390^{Ba}
	15	8543^{Ac}	8897^{Ab}	8937^{Ab}	9783^{Aa}
Syneresis (ml/5g)	Fresh	2.58^{Aa}	0.70^{Ab}	0.44^{Ab}	1.06^{Ab}
	3	2.73^{Aa}	0.76^{Ab}	0.45^{Ab}	1.13^{Ab}
	7	2.90^{Aa}	0.84^{Ab}	0.48^{Ab}	1.22^{Ab}
	15	2.97^{Aa}	0.95^{Abc}	0.53^{Ac}	1.36^{Ab}
Water holding capacity (%)	Fresh	48.47^{Ad}	65.94^{Cb}	76.29^{Aa}	58.87^{Ac}
	3	45.33^{Bd}	64.88^{BCb}	76.06^{Aba}	57.30^{ABc}
	7	42.09^{Cd}	63.20^{Bb}	75.40^{ABa}	55.52^{Bc}
	15	40.67^{Cd}	60.99^{Ab}	74.47^{Ba}	52.71^{Cc}

Means with different capital letters within each column are significant at 5 % level.
Means with different small letters within each row are significant at 5 % level.

Table 4: Textural profile yoghurt stabilized with different levels of dried taro mucilage extract (DTME)

Parameter	Cold storage period (day)	Yoghurt stabilization level with DTME			
		Nil (control)	0.1 %	0.3 %	0.5 %
Hardness (N)	Fresh	2.91^{Dc}	3.10^{Db}	3.40^{Da}	3.00^{Dbc}
	3	3.21^{Cc}	3.61^{Cb}	4.10^{Ca}	3.32^{Cc}
	7	3.45^{Bc}	3.98^{Bb}	4.62^{Ba}	3.57^{Bc}
	15	3.64^{Ac}	4.25^{Ab}	4.99^{Aa}	3.78^{Ac}
Cohesiveness	Fresh	0.35^{Bc}	0.39^{Bb}	0.47^{Da}	0.31^{Ad}
	3	0.37^{ABc}	0.42^{ABb}	0.53^{Ca}	0.33^{Ad}
	7	0.38^{ABc}	0.44^{ABb}	0.57^{Ba}	0.34^{Ac}
	15	0.39^{Ac}	0.46^{Ab}	0.60^{Aa}	0.34^{Ad}
Springiness (mm)	Fresh	0.55^{Bb}	0.66^{Aa}	0.67^{Da}	0.57^{Bb}
	3	0.58^{Ab}	0.70^{Aa}	0.73^{Ca}	0.60^{Ab}
	7	0.60^{Ab}	0.73^{Aa}	0.77^{Ba}	0.62^{Ab}
	15	0.60^{Ab}	0.75^{Aa}	0.80^{Aa}	0.63^{Ab}
Gumminess (N)	Fresh	1.02^{Dc}	1.21^{Db}	1.60^{Da}	0.93^{Dd}
	3	1.19^{Cc}	1.52^{Cb}	2.17^{Ca}	1.10^{Cd}
	7	1.31^{Bc}	1.75^{Bb}	2.63^{Ba}	1.21^{Bd}
	15	1.42^{Ac}	1.96^{Ab}	2.99^{Aa}	1.29^{Ad}
Chewiness (N*mm)	Fresh	0.56^{Dc}	0.80^{Db}	1.07^{Da}	0.53^{Dc}
	3	0.69^{Cc}	1.06^{Cb}	1.59^{Ca}	0.66^{Cc}
	7	0.79^{Bc}	1.28^{Bb}	2.03^{Ba}	0.75^{Bc}
	15	0.85^{Ac}	1.47^{Ab}	2.40^{Aa}	0.81^{Ac}

Means with different capital letters within each column are significant at 5 % level. Means with different small letters within each row are significant at 5 % level.

Table 5: Microbiological situation expressed as log of colony forming unit (CFU) per gram (g) of yoghurt stabilized with different levels of dried taro mucilage extract (DTME)

Microorganism (CFU/g)	Cold storage period (day)	Yoghurt stabilization level with DTME			
		Nil (control)	0.1 %	0.3 %	0.5 %
Lactic Acid Bacteria	Fresh	7. 81	7.83	7.83	7.84
	3	7.82	7.86	7.87	7.90
	7	7.84	7.88	7.89	7.93
	15	7.88	7.96	7.98	8.09
Coliform	Fresh	NIL	NIL	NIL	NIL
	3	NIL	NIL	NIL	NIL
	7	NIL	NIL	NIL	NIL
	15	NIL	NIL	NIL	NIL
Molds & Yeasts	Fresh	NIL	NIL	NIL	NIL
	3	NIL	NIL	NIL	NIL
	7	NIL	NIL	NIL	NIL
	15	NIL	NIL	NIL	NIL

Table 6: Organoleptic quality of yoghurt stabilized with different levels of dried taro mucilage extract (DTME)

Sensory attribute score	Cold storage period (day)	Yoghurt stabilization level with DTME			
		Nil (control)	0.1 %	0.3 %	0.5 %
Appearance (10 points)	Fresh	7	8	10	6
	3	7	7	9	6
	7	6	7	9	5
	15	6	6	8	5
Body and texture (60 points)	Fresh	41	49	52	44
	3	40	46	52	42
	7	35	43	50	40
	15	34	40	50	37
Flavor (30 points)	Fresh	24	26	28	25
	3	22	25	28	23
	7	21	23	27	20
	15	19	21	25	18
Total score (100 points)	Fresh	72	83	90	75
	3	69	78	89	71
	7	62	73	86	65
	15	59	67	83	60

القضاء على عيب التشريش في الزبادي باستخدام مثبت طبيعى مستخلص من درنات القلقاس

محمد عبد الحليم محمود*, علاء الدين أحمد الحديدى, هشام محمد على, سليم عبد العزيز سليمان.

قسم الألبان، كلية الزراعة، جامعة الأزهر، القاهرة، مصر

* البريد الإلكتروني للباحث الرئيسي:halimshafe.5@azahar.edue.eg

الملخص العربي

استهدفت الدراسة معرفة إلى أي مدى يمكن أن ينجح الهلام المستخرج من درنات القلقاس كمثبت طبيعي في تثبيت قوام الزبادي والقضاء على عيب التشريش الشائع حدوثه في مثل هذا المنتج. لتحقيق هذا الغرض ، تم استخلاص الهلام القلقاسي وتجفيفه وإضافته إلى لبن الزبادي ، وهو لبن جاموسى معدل نسبة الدهن به إلى 3.5 % ، تمت الإضافة بنسب صفر(التجربة المقارنة) ، 0.1 ، 0.3 و 0.5٪. ولقد أشارت النتائج المتحصل عليها إلى أن تثبيت الزبادي مع مستخلص القلقاس المجفف (DTME) ارتبط بزيادة في محتوى المواد الصلبة الكلية وقيمة الأس الهيدروجيني واللزوجة .ولقد تحسنت القدرة على الاحتفاظ بالماء (WHC) وجميع معايير تحليل خواص التركيب (TPA) وهي الجمودة hardness والتماسك cohesiveness والمطاطية springiness والصمغية gumminess والمضغ chewiness بالإضافة إلى السمات الحسية بما في ذلك المظهر والقوام والتركيب والنكهة ودرجات التحكيم الكلية بإضافة DTME بشرط أن مستوى الإضافة لا يتجاوز 0.3٪. بينما لم تتأثر نسب كل من البروتين والدهون والرماد وكذلك عدد بكتيريا حمض اللاكتيك ، بينما انخفضت نسبة الحموضة المقدرة بإضافة DTME حتى 0.5٪. تم تقليل انفصال الشرش عندما تم رفع مستوى DTMEإلى 0.3٪. خلال فترة التخزين المبرد لمدة 15 يومًا، ارتفعت جميع الدلالات السابقة تدريجياً باستثناء قيمة الأس الهيدروجيني، WHC ودرجات تحكيم جميع المعايير الحسية حيث أن جميعها إنخفضت تناسبيا مع فترة التخزين المبرد للزبادي. أدت النتائج السابقة إلى استنتاج أن DTME يمكن أن يقضى عيب التشرش بنجاح لو تمت إضافته إلى لبن الزبادي بنسبة 0.3٪.

الكلمات الاسترشادية: بكتيريا حامض اللاكتيك, سعة الاحتفاظ بالماء, تحليل ملف القوام.