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THE CHANGES IN COMPOSITION OF UHT MILK DURING STORAGE AT DIFFERENT TEMPERATURE

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ABSTRACT

The changes in composition and some properties of full-cream and non-fat UHT milk were examined during storage period of 6 months at room (20-30°C) and in an incubator at (40±0.5°C) .

The attained results showed that a gradual decrease occurred in the pH, TS, protein, fat and ash content, whereas the acidity values and weight of sediment gradually increased. The rate of change was more pronounced in non-fat UHT milk and at incubator temperature than at room temperature.

In all UHT milk samples, total N and casein N gradually decreased during storage, whereas non-casein N and non-protein N and their values calculated as % of on TN increased to greater extent in non-fat UHT milk. This was more pronounced at the higher temperature.

Browning of milk samples and the prepared acid casein was observed with advancing storage time especially in non-fat UHT milk and at the higher temperature.

INTRODUCTION

The demand for processes which allow an ecologically friendly and high quality production of products with a long shelf life led to the question of introducing ultra-high-temperature (UHT) milk in Egypt. This is quite important for the hot climate countries and is expected to remedy some of the problems facing the marketing of short shelf-life products such as pasteurized milk.

On the other hand, the major problems facing UHT milk production are the changes in quality during storage especially fat separation and destabilization of milk protein resulting in gelation or the formation of fine precipitates. Such effects beside the browning may reduce the acceptability of the product.

However, it was reported in the literature that many factors could affect the quality of UHT milk. The shelf-life of UHT milk is dependent on the quality of the raw milk (Gillis *et al.*, 1985). The effect of storage time and temperature may be greater than that of the heat treatment itself (Renner and Schmidt,1981 ; Manji *et al.*, 1986; Renner,1988; Mehanna and Gönc, 1988).

The objectives of this research were to follow the composition and some properties of UHT milk and the changes that occur in the product during storage at different temperatures.

MATERIALS AND METHODS

Commercial UHT cow's milk samples in a laminated 1 L cartons were obtained from Juhayna Company for food Industries (6th October City).

The full-cream and non-fat milk samples were grouped into two categories for storage at room (20-30°C) and incubator (40±0.5°C) temperatures until their expiry date of 6 months.

The samples were analysed at one month intervals for pH, acidity, TS, fat and ash content as described by Ling (1963). Total N, non-casein N soluble at pH 4.6 and non-protein N soluble in 12% TCA were determined using the semi-micro Kjeldahal procedure (Ling, 1963). Casein N was calculated by difference. Total volatile fatty acids (TVFA) were assessed as given by Kosikowski (1978), whereas alcohol test expressed as the weakest ethanol concentration when added to an equal volume of milk caused clotting was done as described by White and Davies (1958).

Acid casein was precipitated after removing fat by centrifugation at room temperature. The pH of the diluted skim milk (1:1) was reduced to pH 4.6 by dropwise addition of 1 M-HCL with continuous stirring for about 30 min. The prepared casein was washed several times with distilled water of pH 4.6 and dried using ethanol.

RESULTS AND DISCUSSION

The data illustrated in Table (1) reveal that the pH and acidity values of UHT milk slightly changed during the storage period. This changes was more pronounced when full-cream UHT milk was kept at the higher temperature of 40±0.5°C . Thus, the pH values gradually decreased, whereas the acidity gradually increased. In expired samples much lower pH and higher acidity values were recorded especially at the higher storage temperature. These findings are in a full agreement with those given by Mehanna and Gönc (1988), AlKanhal *et al.* (1994) and Al-Saleh *et al.* (1995). The mentioned authors reported that the higher was the storage temperature, the lower were the pH and the higher were the acidity values of UHT milk.

It seems from Table (1) that storage period and storage temperature had no effect on TS content since a slight decrease was recorded in this respect. On the other hand, protein content suffered from a great change especially in milk samples stored in an incubator. This was also true with respect to fat content. This was more pronounced when protein and fat were calculated on dry matter basis. Mehanna and Gönc (1988) gave the same trend of results for directly and indirectly UHT milk. Moreover, Alkanhal *et al.* (1994) and Al-Saleh (1995) found that fat separation of UHT milk was zero at the beginning of storage and increased significantly with time and temperature of storage.

TVFA had the same value of 0.14 in fresh and stored full cream UHT milk (Table 1) kept at room temperature, whereas in samples stored at 40±0.5°C, TFVA gradually increased reaching the maximum value of 0.16 after 2 months of storage.

Data given in Table (1) show that the minimum ash content was recorded in all UHT milk samples at the end of storage period. The samples stored at the higher temperature had the lowest value. In this respect Mehanna and Gönc (1988) reported that total ash content decreased in all milk samples analysed during storage, whereas, storage temperature had no probable effect in this respect.

Stability of milk to ethanol seems to be not affected by storage period or temperature. Table (1) reveals that all milk samples gave negative results in this respect. Mehanna and Gönc (1988) demonstrated that the higher was the storage temperature, the lower was the stability. However, White and Davies (1958) mentioned that such stability is mainly due to many factors such as acidity of milk state and nature of caseinate complex.

Table (1) :The changes in the chemical composition and some properties of full-cream UHT milk during 6 months of storage at room temperature (A) and in incubator (B)

Property	A					B				
	Storage time (mon.)					Storage time (mon.)				
	Zero	2	4	6	E*	Zero	2	4	6	E*
PH	6.94	6.53	6.50	6.49	6.30	6.94	6.32	6.30	6.24	5.92
Acidity, %	0.18	0.19	0.20	0.20	0.25	0.18	0.22	0.25	0.28	0.36
TS, %	12.99	12.73	12.46	12.39	12.13	12.99	12.99	12.90	12.59	12.19
Protein, %	3.79	3.79	3.39	3.38	3.22	3.79	3.00	2.92	2.35	2.44
Protein/TS, %	29.18	29.77	27.20	27.28	26.55	29.18	23.09	22.63	18.66	20.01
Fat, %	4.0	3.8	3.4	3.4	3.4	4.0	3.9	3.4	3.4	3.2
Fat/TS, %	30.79	29.85	27.87	27.44	28.03	30.79	30.02	26.36	21.00	26.25
TVFA**	0.14	0.14	0.14	0.14	0.14	0.14	0.16	0.16	0.16	0.16
Ash, %	0.78	0.79	0.76	0.75	0.66	0.78	0.75	0.77	0.60	0.56
Stability to ethanol	Nc***	Nc	Nc	Nc	Nc	Nc	Nc	Nc	Nc	Nc
Weight of recipitate, g	-	-	-	0.01	0.20	-	0.21	0.23	0.65	0.54

***E represents an expired milk samples of 8 months old.**
**** TVFA expressed as ml 0.1 N NaOH/10 ml**
***** Nc= No clotting with absolute ethanol.**

It may be of interest to note that all the prementioned changes in physico-chemical and chemical properties of milk were accompanied by formation of sediment on the bottom of cartons. This was noticed by the visual examination of the packages after collecting milk samples. At the end of storage period at room temperature weight of the sediment was 10 mg whereas with the samples stored in the incubator the weight of sediment gradually increased from zero at the beginning to 210, 230 and 650 mg after 2, 4 and 6 months of storage, respectively. This agrees with the finding of Mehanna and Gönc (1988). Hostettler (1981) mentioned that the formation of sediment (fat-protein complex) deposited on bottom of carton became apparent during storage of UHT milk. Alkanhal *et al.* (1994) demonstrated that the level of sedimentation was very low during storage of fresh and

recombined UHT treated milk (0-1.3 on a 5 point scale). It increased slightly with storage time and temperature in all samples.

Regarding the non-fat UHT milk samples, it is well known that full-fat and non-fat UHT milk samples were processed in similar systems. So, it may be expected similar trends of changes in chemical and physico-chemical properties of all milk samples on storage. Similar effects of storage period and storage temperature were recorded when non fat milk samples were kept for 6 months at room and incubator temperatures (Table 2).

Table (2): The changes in the chemical composition and some properties of non-fat UHT milk during 6 months of storage at room temperature (A) and in incubator (B)*

Property	A					B				
	Storage time (mon.)					Storage time (mon.)				
	Zero	2	4	6	E	Zero	2	4	6	E
PH	6.94	6.53	6.29	6.29	6.09	6.25	6.17	6.17	6.06	5.84
Acidity, %	0.18	0.19	0.20	0.21	0.24	0.18	0.22	0.26	0.34	0.35
TS, %	10.24	10.16	10.02	10.22	9.89	10.24	10.25	10.12	10.12	9.84
Protein, %	3.86	3.71	3.71	3.08	2.79	3.86	3.57	3.29	3.00	2.68
Protein/TS, %	37.70	36.51	37.02	30.14	28.21	37.70	34.83	32.51	29.64	27.23
Fat, %	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.7	0.7	0.7
Fat/TS, %	5.86	5.90	5.99	6.85	7.10	5.86	6.85	6.92	6.92	7.11
TVFA	.14	0.14	0.14	0.15	0.16	0.14	0.15	0.16	0.17	0.17
Ash, %	0.82	0.75	0.78	0.82	0.70	0.82	0.82	0.81	0.79	0.70
Stability to ethanol	Nc	Nc	Nc	Nc	Nc	Nc	Nc	Nc	Nc	Nc
Weight of recipitate, g	-	-	0.04	0.16	0.50	-	0.04	0.75	0.75	1.20

***see legend to Table (1) for details.**

In general, the changes in the pH of stored UHT milk were previously reported by Manji *et al.* (1986) and Kohlmann *et al.* (1991) and attributed to a reduction in the positive charge on the protein due to the reaction of the NH_2 group of lysine with lactose in the Maillard reaction (Andrews *et al.*, 1977).However, the residual amount of fat in non-fat UHT milk was accompanied by a gradual increase in TVFA content in milk stored at the high temperature (Table 2). Many studies used acid degree value (ADV) as an index for lipolysis during storage of UHT milk. Renner (1988) observed no change in the ADV of UHT milk during storage at refrigerator temperature but ADV increased in UHT milk stored at 20 or 38°C. This was also reported by Alkanhal *et al.* (1994) and Al-Saleh *et al.* (1995). Locally, Shahin and Fahmy (1988) found that the free fatty acids content of recombined UHT milk was greatly affected by the storage temperature.

Table (3) reveals the changes in some nitrogenous components as affected by storage time and temperature of full-cream UHT milk, whereas Table (4) shows the same for non-fat UHT milk. It is clear that the changes in this respect in all milk samples followed the same trend but more pronounced in non-fat UHT milk. A gradual decrease in TN and casein N was recorded during storage of all milk samples. Storage temperature seems to have

greater effect on casein N. The higher was the storage temperature, the lower was the casein N content. However, the percentages of casein N/TN in all milk samples gradually decreased on storage and those of non fat UHT milk were always lower than those of full-cream UHT milk at any given storage temperature. Such changes in TN and casein N were accompanied by a gradual increase in both non-casein nitrogen (NCN) and non-protein nitrogen (NPN).

Table (3): The changes in some nitrogenous components expressed as mg/100 ml and as percentages of nitrogen fraction on total nitrogen (between parenthesis) during storage of full-cream UHT milk at room temperature (A) and in incubator (B)*

Property	A					B				
	Storage time (mon.)					Storage time (mon.)				
	Zero	2	4	6	E	Zero	2	4	6	E
Total N.	594	594	538	530	504	594	470	458	526	540
Casein N.	567	567	508	500	469	567	440	424	486	491
	(95.5)	(95.5)	(94.4)	(94.3)	(93.1)	(95.5)	(93.6)	(92.5)	(92.4)	(90.9)
Non-Casein N.	27	27	30	30	35	27	30	34	40	49
	(4.5)	(4.5)	(5.5)	(5.7)	(7.5)	(4.5)	(6.4)	(7.4)	(7.0)	(9.1)
Non-protein N.	21	20	22	24	29	21	23	25	29	35
	(3.5)	(3.4)	(4.1)	(4.5)	(5.7)	(3.5)	(4.9)	(5.5)	(5.5)	(6.5)

*E represents an expired milk samples of 8 months old.

Table (4): The changes in some nitrogenous components expressed as mg/100 ml and as percentages of nitrogen fraction on total nitrogen (between parenthesis) during storage of non-fat UHT milk at room temperature (A) and in incubator (B)*.

Property	A					B				
	Storage time (mon.)					Storage time (mon.)				
	Zero	2	4	6	E	Zero	2	4	6	E
Total N.	605	582	582	482	437	605	560	515	470	420
Casein N.	575	549	537	438	392	572	527	475	423	375
	(94.5)	(94.3)	(92.3)	(90.7)	(89.7)	(94.5)	(94.1)	(92.2)	(90.0)	(89.3)
Non-Casein N.	33	33	45	44	45	33	33	40	47	45
	(5.5)	(5.7)	(7.7)	(9.1)	(10.3)	(5.5)	(5.9)	(7.8)	(10.0)	(10.7)
Non-protein N.	23	23	29	30	30	23	26	30	32	30
	(3.8)	(4.0)	(5.0)	(6.2)	(7.0)	(3.8)	(4.6)	(5.9)	(6.8)	(7.1)

*E represents an expired milk samples of 8 months old.

Table (3) shows the changes in NCN and NCN/TN in full-cream UHT milk, whereas Table (4) shows the same for non-fat UHT milk. In all cases, a gradual increase was recorded. The rate of increase was always higher in non-fat UHT milk and at incubation temperature rather than at room

temperature. This was true with respect to values of NPN and NPN/TN. The higher was the storage temperature, the higher were the recorded values.

This trend of result agrees with the finding of Mehanna and Gönc (1988) ; Shahin and Fahmy (1988). Also, AlKanhal *et al.* (1994) and Al-Saleh (1995) demonstrated that the rate of proteolysis in UHT milk expressed as tyrosine value and free amino groups content increased with storage time and temperature.

The foregoing changes in protein content suggest occurring of an intensine proteolysis during storage of UHT milk. Such proteolysis may be attributed to presence of microbial proteinases in the milk which are not fully inactivated by the UHT treatment (McKellar, 1981 and Gillis *et al.* 1985) and presence of native milk proteases resistant to UHT heat treatment or reactivation of proteases in milk (Harper *et al.*, 1970 and Björck, 1973). In this respect, Manjie *et al.* (1986) demonstrated that the plasminogen (Indogenous milk proteinase) survives indirect UHT processing.

The visual examination of milk samples during storage reveals development of brown colour with different rates. The degree of browning was less in full-cream UHT milk than in non-fat samples and at room temperature than at incubator temperature. In all cases, the advancing was the storage time, the higher was the development of the colour. This agrees with the sensory results of Mehanna and Gönc (1988). They demonstrated that the higher was the storage temperature, the lower were the scoring points given for UHT milk samples. Alkanhal *et al.* (1994) and Al-Saleh *et al.* (1995) followed the extent of Maillard browning during storage of UHT milk samples. They reported that type of UHT milk, storage period and temperature were the main factors responsible for the degree of browning. However, when acid casein was prepared from UHT milk samples, similar findings were observed.

Fig's (1) and (2) reveal degree of brown colour in the casein samples. It seems that the browning was higher in casein of non-fat UHT milk especially in samples stored at the higher temperature. This wight be attributed to reaction products of Maillard reaction. Mottar *et al.* (1979) and Blanc and Odet (1981) mentioned that one of the first reaction products of the Millard reaction is hydroxymethyl-furfural (HMF), whose formation depends on the heating and storage temperature, whereas Renner and Schmidt (1981) demonstrated that such products could be responsible for the organoleptic changes which occur in UHT milk during extended storage.

In tis respect, Manji *et al.* (1986) found an increase in the concentration of HMF in UHT milk stored at 30 or 40°C, whereas Renner (1988) reported that during storage of UHT milk the Millard reaction would proceed to an appreciable extent only when the storage temperature was above 20°C.

From the foregoing results it may be concluded that storage of UHT milk at high ambient temperatures during the summer season in Egypt might reduce its acceptability. Therefore, storage in air-conditioned stores or in refrigerators or reduction of the UHT milk storage period is recommended.

Generally, further research is required to determine a suitable shelf life of UHT milk produced in Egypt especially that consumed in summer.

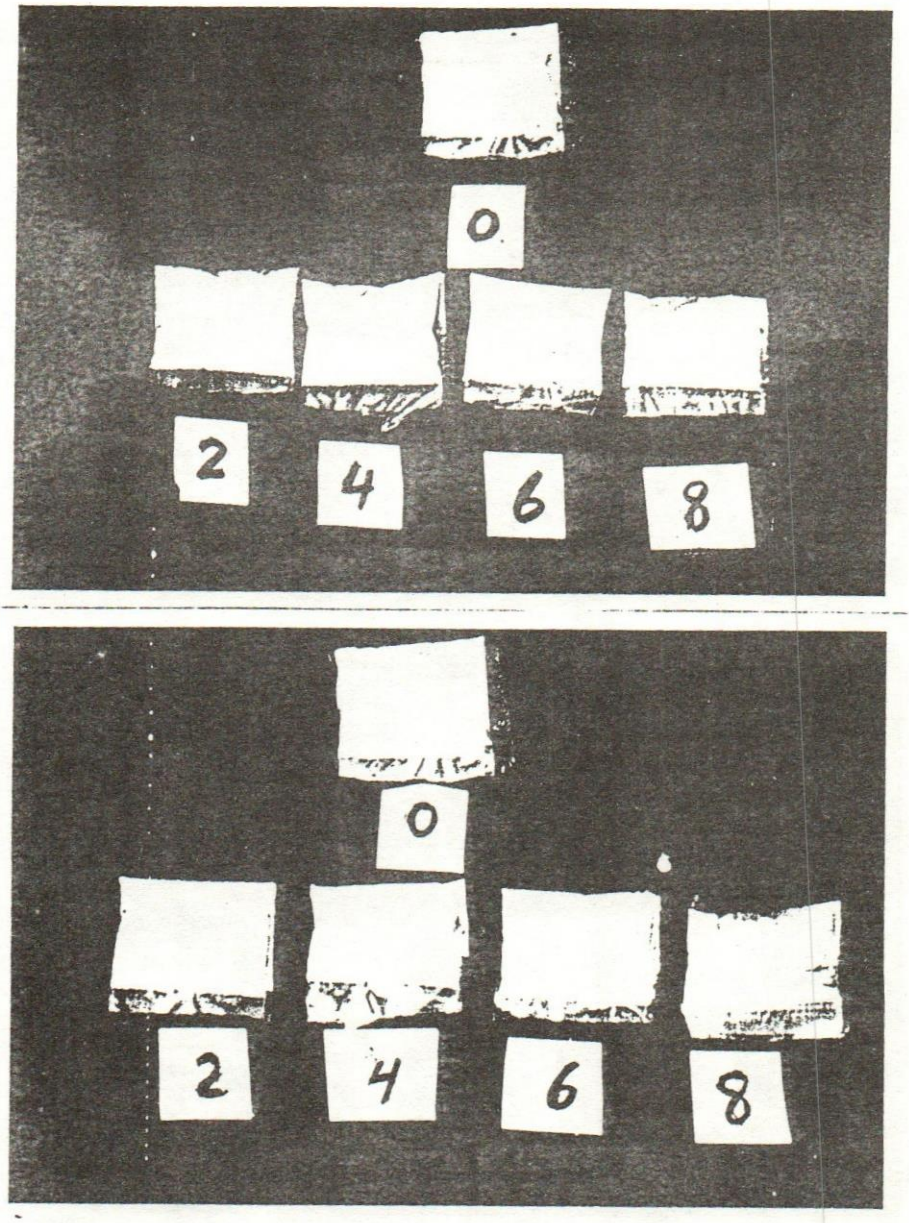

Fig. (1): Degree of browning observed in casein samples prepared from full-cream UHT milk stored for 8 months at room (Upper) or incubator (lower) temperatures. No.8 represents an expired samples.

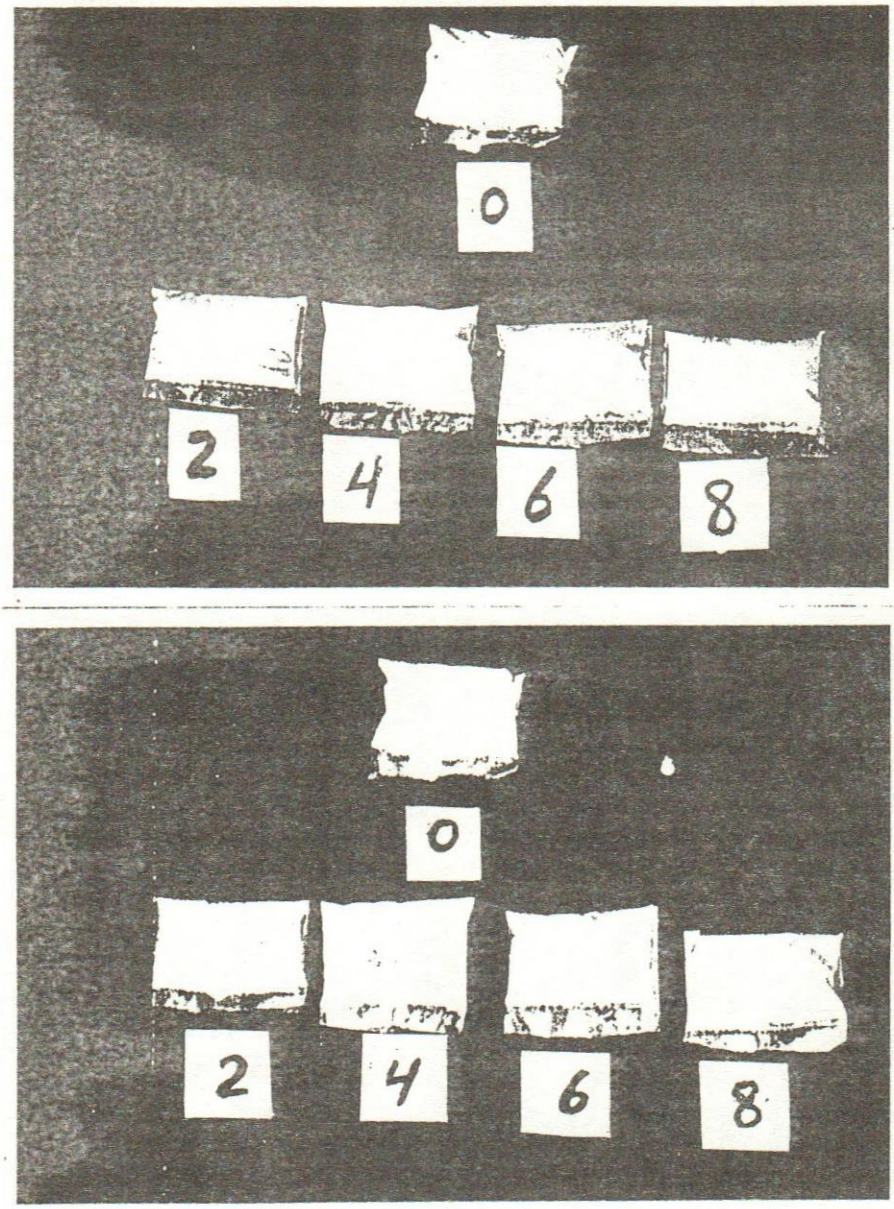

Fig. (2): Degree of browning observed in casein samples prepared from non-fat UHT milk stored for 8 months at room (Upper) or incubator (lower) temperatures. No.8 represents an expired samples.

REFERENCES

Alkanhal, H. A. ; I. H. Abu-Lehia and A. A. Al-Saleh (1994). Changes in the quality of fresh and recombined ultra-high temperature treated milk during storage. Int. Dairy J. 4: 221.

Al-Saleh, A. A. ; H. A. Alkanhal and I. H. Abu-Lehia (1995). Chnages in the quality of recombined UHT milk processed by direct and indirect heating system during storage. J. King. Saud. Univ., Vol. 7, Agric. Sci.: 165.

Andrews, A. T. ; B. E. Brooker and Hobbs, D. G. (1977). Properties of aseptically packed ultra-heat-treated milk. Electron microscopic examination of changes occurring during storage. J. Dairy Res. 44: 283.

Björck, L. (1973). Modifications of casein in ultra-high-temperature treated milk during storage. Milchwissenschaft, 28: 291.

Blanc, B. and G. Odet (1981). New monograph on UHT milk. IDF Doc. No. 133 Chapter 2 B-Appearance, flavour and texture aspects. Recent developments. 25.

Gillis, W. T. ; M. F. Cartledge ; I. R. Rodriguez, and E. J. Suares, (1985). Effect of raw milk quality on ultra-high-temperature processed milk. J. Dairy Sci., 68: 2875.

Harper, W. J. ; J. E. Hidalgo and E. M. Mikolajcik (1970). *Bacillus cereus* protease as a factor in gelation of sterilized dairy products. XVIII Int. Dairy Congr. IE, 192.

Hostettler, H. (1981). New monograph on UHT milk. IDF Doc. No. 133. Chapter 12: History of the development of UHT processes: 132.

Kohlmann, K. L. ; S. S. Nielsen and M. R. Ladisch (1991). Effect of low concentration of added plasmin on ultra-high temperature processed milk. J. Dairy Sci., 74:1151.

Kosikowski, F. V. (1978). Cheese and Fermented Milk Food. 2nd Ed., Cornell Univ., Ithaca, New York.

Ling, E. R. (1963). A text Book of Dairy Chemistry. Vol. 2. 3rd Ed., Chapman and Hall Litd. London.

Manji, B. ; Y. Kakuda and D. R. Arnott (1986). Effect of storage temperature on age gelation of ultra-high temperature milk processed by direct and indirect heating systems. J. Dairy Sci., 69: 2994.

McKellar, P. C. (1981). Development of off-flavour in ultra-high-temperature and pasteurized milk as a function of proteolysis. J. Dairy Sci., 64: 2138.

Mehanna, N. M. and S. Gönc (1988). The changes in composition and properties of directly and indirectly processed UHT milk during storage. Pakistan J. Sci., Ind. Res. 31: 527.

Mottar, J.; G. Waes ; R.Moermans and M. Naudts (1979). Sensoric changes in UHT milk during uncooled storage. Milchwissenschaft, 34: 257.

Renner, E. (1988). Storage stability and some nutritional aspects of milk powders and ultra-high-temperature products at high ambient temperatures. J. Dairy Res. 55: 125.

Renner, E. and R. Schmidt (1981). New monograph on UHT milk. IDF Doc. No. 133. Chapter 3: Chemical and physicochemical aspects: 49.

Shahin, Y. and M. A. Fahmy (1988). Lipolysis and proteolysis in UHT treated recombined milk during storage. Egyptian J. Dairy Sci., 16: 191.

White, J. C. D. and D. T. Davies (1958). The relation between the chemical composition of milk and the stability of the caseinate complex. 1: General introduction, description of samples, methods and chemical composition of samples. J. Dairy Res. 25: 236.

التغيرات الحادثة فى تركيب اللبن المعقم UHT خلال فترات التخزين وعلى درجات حرارة مختلفة

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اهتمت الدراسة بتتبع التغيرات فى تركيب وبعض خواص اللبن كامل الدسم واللبن الخالى من الدهن المعامل بدرجات حرارة عالية خلال فترة التخزين الممتدة الى ٦ شهور على درجة حرارة الغرفة (٢٠-٣٠م) وعلى حرارة اعلى (٤٠±٠,٥م).

أوضحت النتائج المتحصل عليها حدوث تناقصا تدريجيا فى قيم الرقم الهيدروجينى ، الجوامد الكلية ، البروتين ، الدهن ، الرماد . بينما زادت تدريجيا قيم الحموضة وأوزان المادة المترسبة اسفل وعلى جدران العبوة الداخلية . وهذه التغيرات كانت اكثر وضوحا فى اللبن الخالى من الدهن وعلى درجة حرارة التخزين المرتفعة مقارنة بحرارة الغرفة.

اما بالنسبة للتغير فى صور النتروجين فقد اتضح حدوث تناقصا تدريجيا فى المحتوى من النتروجين الكلى والنتروجين الكازينى بتقدم فترة التخزين وصاحب ذلك زيادة تدريجية فى قيم النتروجين غير الكازينى والنتروجين غير البروتينى وفى قيمهما المنسوبة للنتروجين الكلى. هذا ولقد كانت التغيرات فى قيم صور النتروجين اكثر وضوحا فى اللبن الخالى من الدهن .. وكانت لدرجة حرارة التخزين العالية التأثير الاعلى عن حرارة الغرفة.

الجدير بالذكر ان لون اللبن (خاصة الخالى من الدهن) مال تدريجيا الى اللون البنى خاصة مع تقدم فترة التخزين على درجة الحرارة المرتفعة وانعكس ذلك بوضوح على لون عينات الكازين المحضرة بالترسيب الحامضى.

اشارت الدراسة الى ضرورة اجراء العديد من الدراسات لتحديد فترة صلاحية مناسبة لمثل هذه الالبان خاصة عند تخزينها على حرارة مرتفعة مثل حرارة الصيف فى مصر والدول ذات الجو الحار لما لفترة وحرارة التخزين من تأثير فعال على جودة اللبن المعامل لدرجات حرارة عالية.