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THE CHANGES IN COMPOSITION AND PROPERTIES OF DIRECTLY AND INDIRECTLY PROCESSED UHT MILK DURING STORAGE

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The attained results showed that a slight decrease occurred in pH, viscosity, fat, lactose, total ash and some minerals of directly processed UHT milk, whereas, the acidity values slightly increased. Stability to ethanol was the same in milk samples stored for their expiry date (4 mon.) at different temperatures (5 ± 1^{o}, 15 ± 7^{o} and 30 ± 0.5^{o}). The same was observed for indirectly processed UHT milk samples with exception that a great loss was recorded in the fat and lactose contents as well as the stability to ethanol for milk samples stored at 15 ± 7^{o} and at 30 ± 0.5^{o}. In all UHT milk samples total N, case in N gradually decreased during storage, whereas non-casein N and non-protein N increased to a great extent in samples stored at higher temperatures. Storage at high temperature caused undesirable effects on colour and appearance of UHT milk.

Key words: UHT milk, Composition, Properties, Storage.

INTRODUCTION

The production of sterile milk of long keeping quality by continuous flow processes at a high temperature for short time followed by aseptic packaging has been extensively studied during the last twenty years and has become an accepted procedure for liquid milk processing [1]. The types of UHT plant and the effects of processing on milk and changes in milk during storage have been comprehensively reviewed by Burton [2] and Renner & Schmidt [3].

The purpose of the present study was to follow the changes in the composition and properties of directly and indirectly processed UHT milk during storage at different temperatures.

MATERIALS AND METHODS

UHT cow's milk samples in a laminated 1 L cartons were obtained from a commercial direct heating plant (Pinar Sut., Izmir, Turkey) and indirect heating plant (Mis Sut, Gonen, Turkey). The milk samples were grouped into three categories and stored at 5 ± 1^{o} (in refrigerator), at room temperature (15 ± 7^{o}) and at 30 ± 0.5^{o} until their expiry date (4 mon.). The samples were analysed at 1 mon. intervals for pH, acidity and fat content [4]. Viscosity was measured by means of Hoppler viscosimeter at 20^{o}. Alcohol test was carried out as given by White and Davies [5]. Lactose content was assessed according to the procedure of IDF [6]., and total ash as described in A.O.A.C. [7]. Minerals were determined in samples after digestion with a mixture of sulphuric and perchloric acids (3:1). The flame photometer (Eppendorf, West Germany) was used for calcium, potassium and sodium determinations. Phosphorus content was determined in the digested samples using Eppendorf spectrophotometer at 346 nm. [7]. Total N, non-protein N soluble in 12% TCA and non-casein N soluble at pH 4.6 were measured by the semi-micro kjeldahl procedure [4].

The organoleptic properties of 4 mon. stored milk samples were evaluated by a taste panel consisting of 15 persons. The results were also statistically processed.

Three trials were carried out representing different lots of UHT milk.

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RESULTS AND DISCUSSION

Table 1 illustrates changes in the chemical and physicochemical properties of directly processed UHT milk during storage. No pronounced changes were noticed with respect to acidity development and pH values except for the little changes occurred in milk stored at 30^{o}. The present results are in a good agreement with those reported by Zadow and Chituta [8], who observed a small reduction in pH of UHT milk stored at higher temperature. A slight increase in the viscosity of UHT milk was recorded during the first two months and then it decreased after that. Moreover, milk samples stored in refrigerator showed slightly higher values for viscosity followed by samples stored at room temperature and at 30^{o}. This decrease in viscosity may be due to the decrease occurred in some components of milk during storage. These results are not in agreement with those reported by Harwalkar and Vreeman [9].

Storage temperature had no effect on the stability of UHT milk samples to ethanol (Table 1). After 2 months storage all milk samples gave a positive test with 96% ethanol. On the other hand, no changes occurred in the fat content of UHT milk samples stored in cold, whereas a gradual decrease was observed in milk samples at room temperature and at 30^{o} after 2 mon. (Table 1). Lactose content (Table 1) slightly decreased in all milk samples tested. Moreover, milk samples stored at 30^{o} had the lowest values for lactose content after 2 mon. Total ash content decreased in all milk samples analysed during storage. The results of Table 1 suggested that the storage temperature had no probable effect on the different minerals determined.

Regarding the indirectly processed UHT milk samples it is obvious from Table 2 that samples stored in refrigerator had nearly the same acidity and pH values. A slight decrease was observed in pH values of samples stored at room temperature, whereas, those stored at 30^{o} had always the lowest pH values and slightly higher acidity. Renner and Schmidt [3] mentioned that the reduction in pH values of UHT milk during storage was connected with the inter-action between lactose and milk proteins, and with changes in the calcium phosphate equilibrium. The changes in the viscosity (Table 2) followed the same trend observed in directly processed UHT milk samples. Moreover, a pronounced decrease was noticed with respect to the viscosity of milk samples stored at 30^{o} (Table 2). This decrease may be due to formation of more sediment and the sharp decrease in some milk componentts of the same samples (Table 2). In general milk samples stored in refrigerator were more stable to ethanol than those stored at room temperature, whereas, milk samples stored at 30^{o} showed the lowest alcohol stability with advancing storage time. A gradual decrease in the fat content was observed in all milk samples. Moreover, samples stored at 30^{o} had always

Table 1. Chemical and physico-chemical changes in directly processed UHT milk during storage.

	Storage time (mon.)														
	In refrigerator					At room temperature					At 30 ± 0.5^{o}				
	Zero	1	2	3	4	Zero	1	2	3	4	Zero	1	2	3	4
pH	6.75	6.75	6.75	6.75	6.72	6.75	6.72	6.72	6.72	6.70	6.75	6.70	6.68	6.65	6.60
Titratable acidity %	0.13	0.14	0.14	0.15	0.15	0.13	0.14	0.14	0.15	0.16	0.13	0.14	0.15	0.16	0.18
Viscosity, cp	1.28	1.45	1.45	1.30	1.26	1.28	1.39	1.39	1.27	1.28	1.28	1.32	1.30	1.15	1.08
Stability to etahanol*	NC	NC	96	96	96	NC	NC	96	96	96	NC	NC	96	96	96
Fat, %	3.3	3.3	3.2	3.3	3.3	3.3	3.3	3.2	2.9	2.8	3.3	3.3	3.0	2.80	2.6
Lactose, %	4.85	4.76	4.54	4.45	4.28	4.85	4.75	4.48	4.35	4.28	4.85	4.75	4.46	4.20	3.88
Total ash %	0.78	0.76	0.72	0.67	0.67	0.78	0.74	0.72	0.71	0.67	0.78	0.77	0.70	0.69	0.68
Calcium, mg/100 ml	150	150	145	147	138	150	150	140	142	138	150	148	138	138	132
Phosphorus, mg/100 ml	90	90	92	90	88	90	90	87	90	86	90	90	86	86	81
Potassium, mg/100 ml	125	110	112	110	98	125	115	105	105	96	125	105	105	98	95
Sodium, mg/100 ml	80	75	75	70	62	80	70	70	65	52	80	70	70	62	55

* Expressed as the weakest ethanol concentration caused formation of clots. NC, No clotting with 96% ethanol.

Table 2. Changes on storage in some chemical and physico-chemical properties of indirectly processed UHT milk.

	Storage time (mon.)														
	In refrigerator					At room temperature					At 30 ± 0.5^{o}				
	Zero	1	2	3	4	Zero	1	2	3	4	Zero	1	2	3	4
pH	6.70	6.70	6.70	6.70	6.65	6.70	6.65	6.72	6.62	6.60	6.70	6.62	6.59	6.50	6.50
Titratable acidity, %	0.14	0.15	0.15	0.17	0.17	0.14	0.15	0.15	0.17	0.18	0.14	0.15	0.16	0.18	0.21
Viscosity, cp	1.22	1.28	1.22	1.18	1.10	1.22	1.28	1.18	1.12	1.04	1.22	1.16	1.13	1.13	0.99
Stability to etahanol*	NC	NC	96	96	96	NC	NC	96	96	92	NC	96	88	84	80
Fat, %	3.0	3.0	2.9	2.8	1.9	3.0	3.0	1.5	1.4	0.8	3.0	2.4	2.0	1.4	0.8
Lactose, %	4.82	4.80	4.54	4.30	4.10	4.82	4.75	4.54	4.30	4.00	4.82	4.75	4.40	4.12	2.95
Total ash %	0.75	0.74	0.73	0.68	0.66	0.75	0.75	0.72	0.66	0.65	0.75	0.74	0.72	0.66	0.66
Calcium, mg/100 ml	150	150	141	138	134	150	150	134	138	134	150	148	130	138	130
Phosphorus, mg/100 ml	95	95	95	92	92	95	90	85	80	80	95	84	80	77	77
Potassium, mg/100 ml	135	135	133	130	120	135	135	122	118	115	135	130	110	108	115
Sodium, mg/100 ml	75	75	73	68	64	75	71	64	64	51	75	69	64	64	51

* Expressed as the weakest ethanol concentration caused formation of clots. NC, No clotting with 96% ethanol.

the lowest fat content. This may be due to the insufficient homogenization and high storage temperature. The visual examination of packages showed more pronounced sediment and fat separation in the samples stored at 30° and to less extent in samples stored at room temperature. Hostettler [1] mentioned that the formation of sediment, fat-protein complex, deposited on bottom of carton became apparent during storage of UHT milk. The present results are in agreement with those given by Samuelson and Holm [10] and contrary to these reported by Perkin *et al.* [11] with respect to sediment formation in directly and indirectly UHT milk. Lactose, total ash and different minerals (Table 2) showed the same trend of results mentioned for directly processed UHT milk.

Table 3 reveals the N distribution in driectly processed UHT milk while Table 4 shows the same for indirectly heated UHT milk. It is clear that changes in N distribution in the two types of milk followed the same trend but more pronounced in indirectly processed milk probably due to formation of more sediment. Total N content (T.N.) decreased during storage at any given temperature. Milk samples stored at 30° had always the lowest values for T.N. followed by those at room temperature. This decrease in T.N. content may be attributed to formation of small quantity of sediment at the bottom of the package. The casein N content decreased sharply during storage. The higher the temperature of storage, the lower was the casein N content. The present results are in good agreement with those of Snoeren *et al.* [12] which can be attributed to proteolysis by a native milk proteases resistant to UHT heat treatment or to reactivation of proteases in milk [13-15]. Moreover, the non-casein N (NCN) and non-protein N (NPN) all increased during storage of UHT milk. It was observed that the higher the temperature, higher were the values of NCN and NPN. The present results are in agreement with those of Samel *et al.* [16].

Table 5 shows the sensory evaluation of UHT milk at the end of storage period (4 mon.) as affected by the

Table 3. The changes, on ageing, in some nitrogenous components of directly processed UHT milk.

	Storage time (mon.)				
	Zero	1	2	3	4
Storage in refrigerator					
Total N. mg/100 ml.	515	515	509	488	450
Casein N. mg/100 ml	459	459	447	410	362
Casein N/total N(%)	89.1	89.1	87.8	84.0	80.4
Non casein N. mg/100 ml.	56	56	62	78	88
Non casein N/total N(%)	10.9	10.9	12.2	16.0	19.6
Non protein N. mg/100 ml.	39	39	56	56	56
Non protein N/total N(%)	7.6	7.6	11.0	11.5	12.4
Storage at room temperature					
Total N. mg/100 ml.	515	515	515	472	445
Casein N. mg/100 ml.	459	454	449	388	350
Casein N/total N(%)	89.1	88.2	87.2	82.2	78.6
Non casein N. mg/100 ml.	56	62	66	84	95
Non casein N/total (N(%)	10.9	12.0	12.8	17.8	21.3
Non protein N. mg/100 ml.	39	39	62	59	78
Non protein N/total N(%)	7.6	7.6	12.0	12.5	17.5
Storage at 30°C					
Total N. mg/100 ml.	515	515	505	456	437
Casein N. mg/100 ml.	459	453	438	367	342
Casein N/total N(%)	89.1	88.0	86.7	80.5	78.3
Non casein N. mg/100 ml.	56	62	67	90	95
Non casein n/total N(%)	10.9	12.0	13.3	19.7	21.7
Non protein N. mg/100 ml.	39	39	62	61	80
Non protein N/total N(%)	7.6	7.6	12.3	13.4	18.3

Table 4. The changes in some nitrogenous components of direct heating UHT milk during storage at different temperature

	Storage time (mon.)				
	Zero	1	2	3	4
Storage in refrigerator					
Total N. mg/100 ml.	526	515	515	492	485
Casein N. mg/100 ml.	464	448	448	403	385
Casein N/total N(%)	88.2	87.0	87.0	81.9	79.4
Non casein N mg/100 ml.	62	67	67	90	101
Non casein N/total N(%)	11.8	13.0	13.0	18.3	20.8
Nn protein N. mg/100 ml.	39	39	44	62	67
Non protein N/total N(%)	7.4	7.6	8.5	12.6	13.8
Storage at room temperature					
Total N. mg/100 ml.	526	515	515	495	482
Casein N. mg/100 ml.	465	448	448	405	370
Casein N/total N(%)	88.4	87.0	87.0	81.8	76.8
Non casein N. mg/100 ml	62	67	67	90	112
Non casein N/total N(%)	11.8	13.0	13.0	18.2	23.2
Non protein N. mg/100 ml	39	39	50	62	73
Non protein N/total N(%)	7.4	7.6	9.7	12.5	15.1
Storage at 30°					
Total N. mg/100 ml.	526	513	503	493	478
Casein N. mg/100 ml.	465	446	430	386	350
Casein N/total N(%)	88.4	86.9	85.5	78.3	73.2
Non casein N. mg/100 ml.	62	67	73	106	128
Non casein N/total N(%)	11.8	13.1	14.5	21.5	26.8
Non protein N. mg/100 ml.	39	45	50	67	76
Non protein N/total N(%)	7.4	8.8	9.9	13.6	15.9

Table 5. Range and average score for organoleptic properties of UHT milk stored at different temperatures for 4 months. (average scores of 15 panelists)

Property		Direct A	Direct B	Direct C	Indirect A	Indirect B	Indirect C
Taste	Range	6–9	6–9	6–10	7–10	6–10	5–9
(10)	average	7.92 ± 0.26	7.61 ± 0.27	7.08 ± 0.38	8.46 b 0.27	8.00 ± 0.30	7.23 ± 0.34
Odour	Range	6–10	4–9	3–9	6–10	6–10	6–10
(10)	average	8.08 ± 0.37	7.77 ± 0.46	7.00 ± 0.48	8.23 ± 0.36	8.15 ± 0.36	7.38 ± 0.35
Texture	Range	7–10	7–10	6–10	7–10	7–10	6–10
(10)	average	8.61 ± 0.27	8.38 ± 0.31	8.00 ± 0.36	8.85 ± 0.30	8.46 ± 0.32	8.15 ± 0.36
Colour	Range	4–10	3–10	2–8	7–10	7–10	5-9
(10)	average	7.92 ± 0.34	7.37 ± 0.50	6.31 ± 0.58	8.92 ± 0.24	8.85 ± 0.25	7.31 ± 0.35
Appearance	Range	4–10	4–10	2–9	7–10	7–10	4–9
	average	8.08 ± 0.38	7.54 ± 0.39	6.77 ± 0.50	8.85 ± 0.30	8.54 ± 0.31	7.46 ± 0.42

A, B and C represent storage in refrigerator, at room temperature and at 30^{o} respectively.

storage temperature. The taste of stored UHT milk was slightly affected by the storage temperature. For higher temperature of storage, lower was the average scores for taste. These results are in accordance with previous reports by Mottar *et al.* [17] and Blanc and Odet [18]. Mottar *et al.* [17] mentioned that the uncooled storage exceeding 8 weeks caused highly noticeable changes in the taste of UHT milk. They added the degradation products during uncooled storage of UHT mik appear to unfavourable affect the evolution of the taste to a large extent. The deterioration in the taste of stored UHT milk could be attributed to formation of degradation products derived from milk components [17-18]. Among the UHT milk samples, the samples stored in refrigerator were given highest average value for odour followed by those stored at room temperature and that stored at 30^{o}. Generally, no pronounced effect was observed with respect to influence of storage temperature on the texture of UHT milk samples. However, UHT milk samples stored at 30^{o} had always the lowest values for texture. UHT milk samples stored in refrigerator ranked the highest average score for colour, whereas, samples stored at 30^{o} had the lowest average score. Most panelists rejected the brown colour developed in samples stored at 30^{o} which explained and the low colour scores of these samples. Mottar *et al.* [17] and Blanc and Odet [18] mentioned that one of the first reaction products of the Maillard reaction is hydroxymethyl-furfural (HMF), whose formation depends on the heating and storage temperature, whereas, Renner and Schmidt [3] pointed out that the reactions products of the Millard reaction could be responsible for organoleptic changes which occur in UHT milk during extended stroage. In general, appearance of UHT milk samples followed the same trend of results given for colour, the highest scores were for milk samples stored in refrigerator followed by those stored at room temperature and at 30^{o} respectively.

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