Effect of UHT Processing and Storage Conditions on Physico-chemical Characteristics of Buffalo Skim Milk

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Summary: The obtained results indicated that physico-chemical and nutritional changes in UHT processed buffalo skimmed milk were more pronounced at 45°C than 25°C and 10°C. Duration of storage adversely affected the chemical and nutritional quality of processed milk. A slight decrease in pH, total ash and lactose contents, was observed, whereas acidity was increased on the mentioned storage conditions. Total nitrogen and casein nitrogen contents gradually decreased during storage, whereas non-casein nitrogen (NCN) and non-protein nitrogen (NPN) increased to a great extent in samples stored at higher temperatures. A significant increase in hydroxyl methyl furfural (HMF) values occurred in UHT processed buffalo skim milk at 25°C and 45°C after of 90 days storage. Storage at high temperature (45°C) caused undesirable effects on sensory properties, general quality characteristics and acceptability of UHT buffalo skimmed milk.

Introduction

UHT processed milk is a very popular dairy product in Pakistan. Due to its long shelf life, it is consumed throughout the country. Skim milk is also gaining popularity in the local market due to the elimination of fat which suits to the consumers who are diet and weight conscious. Mostly, this dairy product is used for tea making and very little is consumed for direct drinking.

The production of sterile milk, for long keeping quality by continuous flow processes at a high temperature for short time followed by aseptic packaging, had been extensively studied during the last twenty years and had become an accepted procedure for liquid milk processing [1].

Liquid milk products are especially sensitive to the effects of heat treatment encountered under conventional processing and storage conditions. Lactose may isomerize via the Lobrey de Bruyn-Alberda to Van Ekenstein (LA) transformation, followed by degradation to form acids and sugars. Alternatively, lactose may react with caseins and whey protein of milk systems via the Maillard, or non-enzymatic browning reactions [2]. Most of the macro- and micronutrients are lost during UHT processing of skim milk [3, 4]. It had been reported that at 22°C, there was evidence of proteolysis but no evidence of high molecular weight polymer formation, while at 40°C both proteolysis and high molecular weight polymer formation increased with storage time. The volatile compounds profile and chemical stability of UHT milk bottled in polyethylene terephthalate (PET) were studied along with its shelf life of 60 days at 5°C [5]. It was found that there were insignificant changes in pH while ascorbic acid was considerably degraded. Sensory evaluation of processed milk samples revealed that there was no noticeable oxidized or rancid off flavor up to 60 days of storage. Work carried out on nutritional, sensory and physico-chemical characterization [6-8] of protein-standardized UHT milk [9] indicated that nutritional quality was reduced by the addition of skim milk permeate, due to minor decreases in the protein content. However, sensory quality was normal, although the pH shift upon addition of acid whey permeate to milk was minor (from pH 6.7 to pH 6.6), neutralization to pH 6.8 was required to avoid protein coagulation during direct or indirect UHT heating. Effects of homogenization on protein distribution during storage of UHT milk led to lower levels of the enzymes that contributed to deterioration during storage. It was observed that this phenomenon, together with an increased complex formation between casein and lactoglobulin, could be responsible for reduced proteolytic degradation [10]. The effect of heat treatment of skim milk on ultrafiltration process on denaturization of protein was examined. It was observed that this was resulted due to the formation of complex structures between heat-denatured whey proteins and casein micelles [11].

Casein micelles in heat treated milk products contained a smaller fraction of the casein molecules than micelles in raw milk, due to dissociation during heat treatment [12].

During storage of UHT milk at 30°C, total nitrogen minus non-casein nitrogen did not change, in autoclaved milk [13]. Therefore, the present study was carried out to observe the physico-chemical changes in UHT processed buffalo skim milk during storage, under varying storage temperature conditions.

Results and Discussion

The results regarding pH and titratable acidity of UHT processed buffalo skim milk are presented in Table-1 shows no change during storage at 10°C. However acidity increased and pH decreased of UHT skim milk during storage at 25°C and 45°C. These results are in agreement with the earlier observations [5]. The increase in titratable acidity was 28.57% at 25°C and 42.8% at 45°C after 90 days. This increase in acidity and decrease in pH during storage of skim milk may be correlated to increase in concentration of lactic acid and other organic acids which resulted from degradation of lactose. Changes in calcium phosphate equilibrium might also be responsible for increase in acidity and decrease in pH of UHT processed skim milk. These results are inconsistent with the previous findings [11, 14, 15], where it was found that acid values increased in UHT processed buffalo skim milk.

Table-1: Effects of storage conditions on pH, titratable acidity, total nitrogen, ash and lactose contents of UHT buffalo skimmed milk.

Storage Time (Days)		Storage Temperature (°C)		
		10	25	45
pH	0	6.75	6.75	6.75
	30	6.75	6.73	6.70
	60	6.74	6.69	6.66
	90	6.74	6.65	6.60
Titratable Acidity (%)	0	0.14±0.01	0.14±0.01	0.14±0.01
	30	0.14±0.01	0.15±0.01	0.16±0.01
	60	0.14±0.01	0.17±0.01	0.20±0.01
	90	0.15±0.01	0.19±0.01	0.25±0.01
Total Nitrogen (mg/100ml)	0	*564.3±3.06*	*564.66±4.16*	*566.66±4.16*
	30	*560±2.00*	*558±2.05*	*559.33±6.03*
	60	*559.33±6.04*	*553±2.02*	*551.33±3.51*
	90	*549.33±3.06*	*548.66±4.20*	*544.66±5.51*
Ash (%)	0	0.77±0.01	0.77±0.01	0.77±0.01
	30	0.78±0.01	0.75±0.01	0.74±0.02
	60	0.75±0.01	0.73±0.01	0.70±0.02
	90	0.74±0.01	0.69±0.02	0.65±0.03
Lactose (%)	0	4.76±0.04	4.75±0.05	4.75±0.05
	30	4.76±0.04	4.67±0.04	4.62±0.06
	60	4.72±0.05	4.61±0.05	4.52±0.06
	90	4.64±0.06	4.55±0.07	4.44±0.08

Values represent the average of 3samples (±) standard deviation.

The data presented in Fig. 1 indicate the changes that occurred in nitrogenous components during 90 days storage of UHT-processed buffalo skim milk. Storage at 45°C, casein contents decreased form 470 to 391 mg/100ml at 90th day. This decrease was due to denaturation of casein nitrogen by milk proteases resistant to UHT-heat treatment or reactivation of proteases during storage [3, 16, 17]. Similarly NCN increased from 81 to 126 mg/100ml after 90 days storage. This resembles with the work which showed that both NCN and NPN also increased during storage [15]. Maximum increase from 36 to 50 mg/100ml was observed during storage 90 days at 45°C. These results are in agreement with the previous findings [18-20], where as it had been found that NPN and other changes in protein fractions were accelerated by increased storage temperature. These changes included dissociation of casein whey protein complex, confirmation of changes of casein molecules including breakage of micelle structures, interaction of beta-lactoglobulin and casein disulphide (s-s), exchange reactions, phosphorylation of casein and carbohydrates.

The data presented in Table-1 indicate a gradual decrease in ash contents during storage of UHT processed buffalo skim milk which decreased from 0.77 to 0.65% after 90 days storage at 45°C.

The data presented in Table-1 and Fig. 1 also indicate that a decrease in lactose and increase in HMF was observed to various extents. These changes were more prominent during storage of UHT processed buffalo skim milk at 45°C. Lactose contents decreased from 4.75 to 4.44% at 45°C, from 4.75 to 4.55% at 25°C and from 4.76 to 4.64 at 10°C after 90 days storage (Table-1). This decrease was due to formation of HMF during storage of UHT processed buffalo skim milk. HMF value increased from 7.86 to19.00 μmole/L and from 7.86 to14.00 μ mole/L during storage at 45°C and 25°C respectively. Formation of HMF had also been reported during storage of UHT cow milk [21].

Sensory quality parameters of UHT processed buffalo skim milk did not show significant change during first 60 days of storage. However, during the last 30 days storage, coagulation of protein appeared at 45°C which adversely affected the sensory characteristics of UHT processed buffalo skim milk. Scores for taste, odor, color, texture and overall acceptability were less at 45°C storage temperature than skim milk stored at 10 and 25°C (Table-2). These results are supported by the findings of earlier workers who observed that undesirable changes in organoleptic characteristics of skim milk occurred due to decomposition of protein as a result of proteolysis process during storage [22, 23].

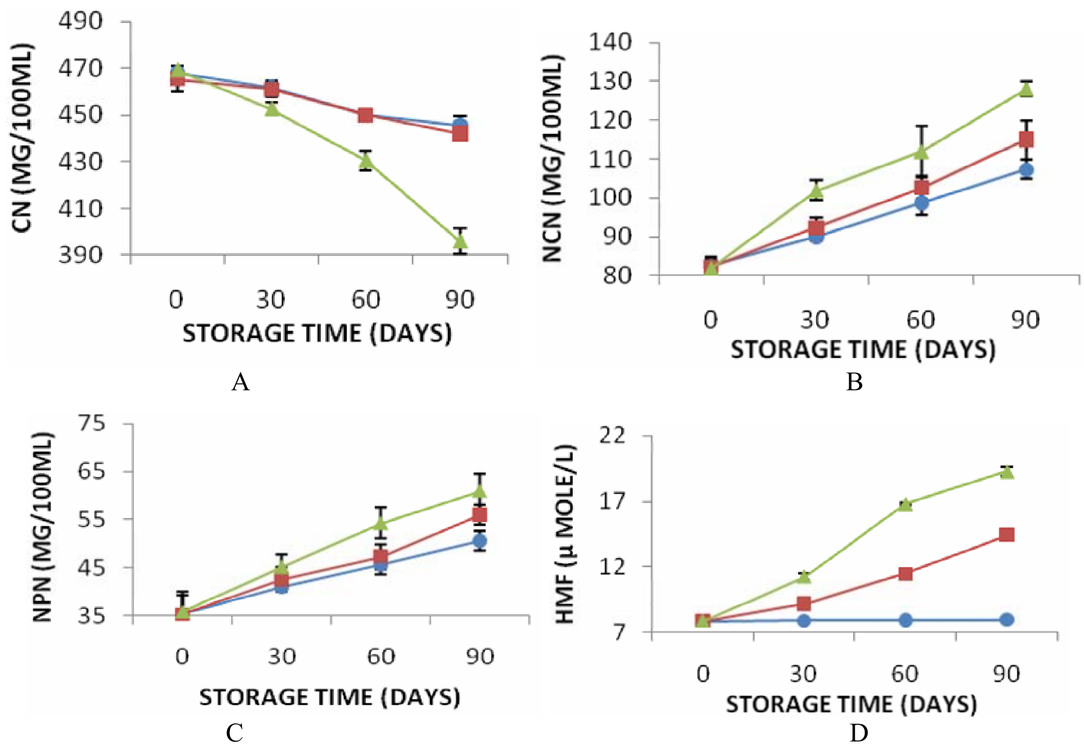

Fig. 1: Evolution of CN (A), NCN (B), NPN (C) and HMF (D) content of UHT buffalo skimmed milks stored at 10°C (●), 25°C (■) and 45°C (▲) for up to 90 days.

Table-2: Sensory evaluation of UHT buffalo skimmed milk after 90 days storage.

Sensory Attributes	Storage Temperature (°C)		
	10	25	45
Taste	8.20	7.90	4.90
Odor	8.40	8.10	5.50
Color	8.31	7.85	5.70
Texture	8.36	7.80	5.60
Overall Acceptability	8.32	7.91	5.43

Experimental

UHT processed buffalo skim milk samples in one liter tetra pack cartons were acquired from the commercial market. The skim milk samples were arranged into three categories and stored at 10, 25 and 45°C up to 90 days. The skim milk samples were analyzed three times each at 30 days intervals for pH, titratable acidity, ash, nitrogenous components and lactose. pH of skim milk sample was determined using a glass electrode pH meter, whereas titratable acidity was measured by titration against 0.1 N sodium hydroxide solution using phenolphthalein as an indicator [24]. Total ash in samples was estimated after ignition of the dried skim milk at 550°C for 6 hours [24], while total nitrogen, casein nitrogen, non casein nitrogen in skim milk samples were determined according to standard methods [24]. Lactose in milk samples was determined spectrophotometrically at 370 nm using phenyl hydrazine solution [25]. HMF values were measured on spectrophotometer (UV spectrophotometer, Hitachi, Japan) at 443 nm after developing color with thiobarbituric acid [26].

Sensory Evaluation

UHT processed skim milk after 90 days was subjected to sensory evaluation by a trained taste panel of ten persons. The samples were assessed for taste, color, odor, texture and overall acceptability using a nine point hedonic scale ranging from 1 for disliked extremely to 9 for liked extremely [27].

Statistical Analysis

ANOVA was carried out using to see if there was a significant effect of different treatments used in this article. Each was analyzed in triplicates. The differences in means were determined using the Duncan test. Significance was established at a level of $P < 0.05$ [28].

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