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Effect of Different UHT Processing Temperatures on Ash and Lactose Content of Milk during Storage at Different Temperatures

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ABSTRACT

Commercial milk and improve quality milk containing total plate count 2.2 × 10^6 and 3.5 × 10^5 cfu/mL and somatic cell count 621,000 and 249,000 per mL, respectively were subjected to different ultra-high temperature (UHT) processing temperatures (135, 138, 141 & 144°C) and stored at 25°C and 40°C temperatures for 90 days. Commercial milk contained significantly lower content of lactose as compared to improved quality milk. More degradation of lactose content was observed in milk stored at 40°C than at 25°C temperature. The lactose content decline in UHT milk processed at a temperature 135°C was lower than at 144°C temperature. Commercial milk possessed higher ash content than improved quality milk. UHT processing and storage temperatures had no influence on ash content of both milk sources. © 2010 Friends Science Publishers

Key Words: Commercial milk; Improved quality milk; Somatic cell count; Total plate count; Storage period

INTRODUCTION

Milk is a secretion from the mammary glands derived from the milking of healthy Halal milch animals (PSQCA, 2008) it should be free from colostrum. Nature has gifted milk with the attributes of an ideal food. It is highly nutritious containing essential nutrients required for the development of all age groups. The stockpile milk nutrients include the energy providing lactose and fat, the bone forming calcium and other minerals, the body building proteins and health promoting vitamins. Pakistan is ranked as a fifth largest milk producing country in the world with milk production of 43.6 billion liters per year (GOP, 2009). Only 4% of the total milk produced is processed and used in urban areas of the country. Milk may be consumed as fresh, boiled and in powder form. Common milk products are yogurt, ghee, butter milk, butter, cheese and ice cream. By weight, milk and its products makes up nearly one-third of all the food consumed in Pakistan. However, per capita availability of milk in Pakistan is less than the recommended levels of 0.5 L per person per day prescribed by World Health Organization (WHO, 2005). With rapid increase in human population and stress to maximize production of food especially in developing countries, demands the use of technologies for more production and preservation of food.

The processors preserve and process the milk by thermal processing to meet the increasing demand of milk round the year in the markets. Various thermal processing techniques are being applied in the dairy industry but among ultra-high temperature (UHT) treated milk has higher acceptability due to hot prolonged summer season in Pakistan. UHT processing is carried out by subjecting milk at a high temperature for a short period of time in order to have a long shelf-life at room temperature (Valero *et al.*, 2001). The thermal processing treatment of milk brings about changes in nutritional, sensoric and technological properties of milk. The intensity of these changes varies widely with changing in processing conditions (Fox & McSweeney, 1998). Milk sterilized by the use of UHT treatment tends to be unstable during storage. This stability is a critical aspect of quality of UHT milk, which limits its use.

Lactose a disaccharide sugar is major carbohydrate of milk commonly referred as milk sugar. Basically the milk of the mammals is the solitary source of lactose (Holsinger, 1998) and ranged from 4.4-5.2% with average content of 4.8%. It is a low glycemic index carbohydrate, which makes this sugar beneficial for diabetics (Brew, 2003). Lactose undergoes changes more readily in milk than in the dry state. A series of reactions take place during heat treatment between amino groups of proteins and aldehyde groups of lactose known Maillard reaction. This reaction is much faster at temperatures above 100°C, which results in a change in color and flavor as well as loss in essential amino acids (lysine & arginine) (Manji & Kakuda, 1988; Alfa-

Laval, 2003). Ash is a mixture, not of original inorganic salts, but of the carbonates and oxides of elements present in the food, phosphorus and sulphur from proteins and lipids are present in ash, while organic ions such as citrate are lost during incineration and the high temperature usually employed in ashing may vaporize certain volatile elements (Fox & McSweeney, 1998).

MATERIAL AND METHODS

Raw milk for UHT processing at commercial dairy plant was collected from two sources:

a. Commercial suppliers

b. Improved quality milk (collected from well managed dairy farms).

The milk from two different sources collected in different storage tanks according to their quality. Analyses were performed on the bulk raw milk in each storage tank. The milk samples were processed by indirect UHT system in a commercial dairy plant. The samples were heated at four different UHT temperatures i.e. 135°C, 138°C, 141°C and 144°C for 3-4 sec. Then aseptically packed in Tetra Pak brick packaging and stored at two different storage temperatures (25°C, 40°C). Samples of the UHT milk were analyzed after processing at 15 days intervals for 90 days of storage period. Three pack of each batch was opened and analyzed.

Total plate and somatic cell counts: The milk samples were tested for total plate count by following the procedure as the methods determined by Cappuccino and Sherman (1996). The test for somatic cell count was carried out by following the reference method of IDF (1984) with some modifications.

Lactose content: Lactose determination was done by the enzymatic method described in AOAC (2000). Sample solution (0.2 mL) was taken in cuvett and incubated for 10 min at 25ºC then 2.2 mL of distilled water was added at 25ºC, 0.2 mL of ethylene diamine tetra acetic acid (EDTA) buffer and 0.1 mL of nicotinamide adenine dinucleotide (NAD) was added. Absorbance of the solution after 3 min was read and recorded as A1. After addition of 0.02 mL of β-galactosidase dehydrogenase read the absorbance as A2. The lactose concentration was calculated by applying the formula.

Ash: The milk was tested for ash content by following the method no 945.46 as given in AOAC (1990). Ash (%) was calculated as given below:

$$Ash\,(\%) = \frac{Wt.\,of\ ash}{Wt.\,of\ sample} \times 100$$

Statistical analysis: The data thus obtained were analyzed by applying analysis of variance under completely randomized design (CRD). To determine the effect of heat treatments, storage temperatures, storage periods on lactose and ash content of UHT processed milk, four factor factorial analysis of variance was applied (Steel *et al.,* 1997).

RESULTS

It is evident from the statistical results that milk sources significantly (P<0.001) affected the ash and lactose content of different UHT processed milk. Lactose content also varied significantly (P<0.01) due to differences in milk sources, storage periods, storage temperatures and UHT treatments. The results further revealed that lactose content of UHT processed milk was also affected due to the interactions between milk sources and storage periods, while ash content of UHT processed milk did not differ significantly (P<0.01) due to all these variables except milk sources.

The results regarding effect of milk sources on ash content of UHT processed milk showed that ash content of UHT processed milk differed significantly (P<0.01) between different milk sources (Table I). The highest ash content (0.86%) was found in commercial milk, while the lowest ash contents (0.82%) was present in IQ milk. The results further showed that UHT processing temperature did not show significant (P>0.05) affect on the ash content of processed milk. The lactose content of UHT processed milk also varied significantly (P<0.01) between milk sources. The commercial milk contained the lowest content of lactose (3.79%), while IQ milk contained the highest lactose content (4.04%). The lactose of the UHT processed milk differed significantly (P<0.01) from 3.57% to 4.09% during 0 to 90 days of storage, this showed a decreasing trend in lactose with progressive increase in storage period. The interaction between storage period and milk sources (Table II) also indicated a declining trend in both type of milk sources. The content of lactose in IQ and commercial milk was 4.19 and 3.99%, respectively at 0 day storage, which decreased to 3.79 and 3.35% in IQ and commercial milk, respectively when milk tested at the expiry of storage period i.e., 90 days. The total drop of lactose in commercial milk was 0.64%, while in IQ milk it was 0.40% during 90 days of storage.

The influence of storage temperature on the lactose content exhibited a significant effect (P<0.01) of storage temperature on the lactose content of UHT processed milk. The highest percentage of (3.93%) lactose was observed in UHT processed milk when stored at a temperature of 25°C, while lower lactose content was found (3.90 %) when stored at 40°C temperature (Table III). As regards the effect of UHT temperature on the lactose content of UHT processed milk, a significant (P<0.01) influence of UHT temperature on the lactose content was observed. The lactose content decline in UHT milk, processed at a temperature 135° was 0.51% (4.14 to 3.63%), at 138°C was 0.51% (4.10 to 3.59) and at 141°C was 0.51% (4.08 to 3.57%) relatively higher decrease of 0.53% (4.03 to 3.50%) was observed when milk processed at 144 temperatures. The difference in lactose content at different temperatures was significant (P<0.01), but non-significant (P>0.05) differences observed in drop of lactose when milk processed at 135, 138 and 141

Table I: Effect of milk sources on ash content of UHT processed milk

UHT temperature (^oC)	Ash (%)	
	Commercial milk	IQ milk
135	0.86	0.81
138	0.85	0.82
141	0.86	0.82
144	0.87	0.83
Mean	**0.86A**	**0.82B**

Means carrying same letters are not significantly different from each other

Table II: Effect of milk sources and storage periods on lactose content of UHT processed milk

Storage period (Days)	Lactose (%)		Mean
	Commercial milk	IQ milk	
0	3.99de	4.19a	4.09A
15	3.97e	4.16a	4.07B
30	3.94f	4.13b	4.03C
45	3.89g	4.08c	3.98D
60	3.78h	4.01d	3.90E
75	3.60i	3.93f	3.76F
90	3.35j	3.79h	3.57G
Mean	**3.79B**	**4.04A**	

Means carrying same small letters are not significantly different from each other

Means carrying same capital letters in a column and rows are not significantly different from each other

Table III: Effect of storage temperature on lactose content of UHT processed milk

Storage period (Days)	Lactose (%)	
	25^oC	40^oC
0	4.09	4.08
15	4.07	4.06
30	4.04	4.03
45	4.00	3.97
60	3.92	3.88
75	3.78	3.74
90	3.59	3.55
Mean	**3.93A**	**3.90B**

Means carrying same letters are not significantly different from each other

Table IV: Effect of UHT temperature on lactose content of UHT processed milk

Storage period (Days)	Lactose (%)			
	135^oC	138^oC	141^oC	144^oC
0	4.14	4.10	4.08	4.03
15	4.12	4.08	4.06	4.01
30	4.09	4.05	4.03	3.97
45	4.04	3.99	3.98	3.92
60	3.95	3.91	3.90	3.84
75	3.82	3.78	3.76	3.69
90	3.63	3.59	3.57	3.50
Mean	**3.97A**	**3.93B**	**3.91C**	**3.85D**

Means carrying same letters are not significantly different from each other

temperatures. Therefore it may be concluded that the differences lie in the initial lactose content after UHT processing, while the storage reflected the same effect for the first three temperatures of UHT processing (Table IV).

DISCUSSION

In the present investigation the difference in the ash and lactose content between the milk sources may due to the poor quality of commercial milk. The adulteration of milk could result a higher level of ash content, because the entire adulterations test are of qualitative nature. Adulteration to a minimum level some times gives negative results for the adulterants. The commercial raw milk has the lower content of solids non-fat (SNF) and lactose, which are reflected in the respective processed product. The elevated microbial and somatic cell count recorded in the commercial milk may also be another reason for reduction in lactose contents as several researchers have associated the reduction in lactose content with high somatic cell count (Kitchen, 1981; Harmon, 1994; Sharif *et al*., 2007). They further reported that mastitis results in tissue damage and decrease the synthetic ability of the enzyme system of the secretory cells and biosynthesis of lactose decreases in the mammary tissue. Reduction of lactose contents in commercial milk might be due to passage of lactose from milk into blood and increased permeability of tissues between milk duct of udder and the blood, which leads to increased steady flow of blood components into the udder and results in alteration of milk composition similarly salt concentration of milk increases with the infection of mastitis, which ultimately results in the high ash content (Shuster *et al*., 1991; Schallibaum, 2001). When the animal suffer from mastitis, a larger amount of low molar mass blood components leak from the blood into the milk, which contains a greater amount of dissolved salts (Walstra *et al*., 1999). Sonea *et al*. (2009) concluded that lactose content decreased and minerals increased in mastitis milk, which also confirms to present results. This is due to the reason of alteration in lactose secretions, which determines a lowering osmotic pressure within mammary gland alveoli. To compensate lower osmotic pressure, higher amount of minerals go in cellular walls. The high ash content may be attributed to higher incidence of mastitis in commercial milk as compared to IQ milk.

A decreasing trend in lactose as a function of storage period might be due to many biochemical reactions generally grouped under the name Maillard reaction are taking place during storage of milk samples. This reaction begins with the attachment of the aldehyde group of lactose with the ε-amino group of lysyl residues from the different milk proteins (Singh & Creamer, 1992). Different modifications in lactose due to series of reactions result in brown pigmented products such as pyrazines and melanoidins, some polymerized molecules (lactuloselysine & fructoselysine) and small acid molecules are also formed during the Maillard reaction (Fox & McSweeney, 1998; Van Boekel, 1998). Rehman *et al*. (2002) also reported a decrease in lactose content and increase in hydroxylmethyl furfural contents during storage of UHT milk as is observed in the present study. In the present case more pronounced changes were observed when milk stored at 40°C than 25°C temperature, this might be due to faster Maillard reaction at higher temperature, which corroborates with the previous studies (Rehman *et al*., 2002; Gaucher *et al*., 2008).

The milk subjected to the highest UHT temperature treatments yielded minimum lactose content, which might be due to extensive lactose breakdown (0.53%) during Maillard reaction as compared to milk expose to lower temperature of processing. Walstra *et al*. (1999) and Cattaneo *et al*. (2008) reported that more lactulose (an intermediate product of lactose breakdown) is formed in UHT milk as more increase in lactulose occurred, when severe heat treatment process was applied in the present study.

In conclusion, the variation in ash and lactose content in the present study may be attributed to the quality of milk, because commercial milk poor in quality showed lower lactose and higher ash content. UHT temperature also exhibited pronounced effect on lactose degradation. The milk subjected to 144°C and stored at 40°C exhibited lower level of lactose content.

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