Pak. j. sci. ind. res. Ser. B: biol. sci. 2017 **60**(1) 46-48

Short Communication

Photo-oxidation of Pasteurized Milk in Polyethylene Pouch Packs

Muhammad Nadeem[a]*, Asif Anwar[a], Rahman Ullah[a], Shakeel Ahmad[a] and Masroor Ellahi Babar[b]

[a]Department of Dairy Technology, University of Veterinary & Animal Sciences, Lahore, Pakistan

[b]Department of Livestock Production, University of Veterinary & Animal Sciences, Lahore, Pakistan

(received January 23, 2015; revised September 15, 2015; accepted December 12, 2015)

Abstract. In the present study photo-oxidative stability of pasteurized milk packaged in polyethylene pouches was investigated. Milk packaged in three layer polyethylene pouch packs was exposed to 400, 600 and 800 l× florescent light at 4 °C for 6 days, compared with a control (stored in dark). Light had a pronounced effect on fat content of milk with no effect on protein, lactose and ash content. Photo-oxidative stability of milk decreased as the intensity of light increased, peroxide value, anisidine value and conjugated dienes increased during the storage period of 6 days, higher values were observed in samples exposed to 800 l× florescent light. After 6 days of storage period, milk exposed to 400 l× florescent light did not reveal any oxidized flavour. The results of this study depicted that polyethylene pouches have the capability to resist photo-oxidation up to 400 l× light.

Keywords: pasteurized milk, photo-oxidation, polyethylene pouches, fluorescent light

Oxidation of unsaturated fatty acids and its results have been studied by Brien and Connor (2011); Richmond (2007); McSweeney and Fox (2003) and Fox and McSweeeney (1998). Photo-oxidation of milk leads to the boost of acetaldehyde and reduction of riboflavin. Oxidation of polyunsaturated fatty acids leads to the formation of numerous volatile and potentially toxic oxidation products (Cladman *et al*., 1998; Jeng *et al*., 1988). The photo-oxidative stability of pasteurized milk in polyethylene pouches has not been studied so far. This study aimed to determine the effect of light of various intensities on photo-oxidation of pasteurized milk in polyethylene pouches.

Collection of milk samples and experimental plan. Fresh pasteurized milk samples of same batch (3.5% fat) packed in 3 layer polyethylene pouch packs (low density polyethylene, linear low density polyethylene and high density polyethylene) of one liter capacity were procured from Lahore and exposed to 400 l×, 600 l× and 800 l× fluorescent light at 4 °C for 6 days, compared with control (3.5% fat) packed in polyethylene pouches stored in dark at same temperature and similar length of storage period. The effect of photo-oxidation on milk composition was determined for 6 days at the interval of 2 days using lactoscan (Julie Z-7, Slovakia). Fat from milk was extracted by the standard method of AOAC (2000). Peroxide value, anisidine value, iodine value and refractive index were determined for 6 days at the frequency of 2 days (AOCS, 1995). Specific extinctions were measured at 232 nm in the ultraviolet region of the spectrum on a double beam spectrophotometer (Anwar *et al*., 2010). Sensory evaluation of pasteurized milk exposed to photo-oxidation was performed by a panel of 10 trained judges on a 9 point scale (1-worst, 9-excellent). The judges were asked to determine oxidized flavour (Larmond, 1987). The experiment was planned in a Completely Randomized Design. The collected data were analyzed through Analysis of Variance Technique. To determine the effect of treatments, storage and their interaction, two way analysis of variance was used. Means of the treatments were compared by Duncan's Multiple Range Test (Steel *et al*., 1997).

Effect of light on milk composition. Light exposed samples at different light intensities (300 l×, 600 l× and 900 l× fluorescent light showed significant changes in different parameters. Light had a pronounced effect on fat content of pasteurized milk but to varying extents (Table 1). The drop in fat content of the experimental samples and control was in the order of $T_3 > T_2 > T_1 > T_0$. A linear correlation between fat content and light strength was observed. The harmful effect of light on oxidation of milk has been well established (Shahidi, 2005). It is evident from the results that light did not

*Author for correspondence;
E-mail: muhammad.nadeem@uvas.edu.pk

Table 1. Fat, protein, lactose and ash contents of pasteurized milk in polyethylene pouch packs exposed to different intensities

Treatments	0-Day	2-Day	4-Day	6-Days
Fat contents				
T_o	3.92±0.02a	3.87±0.06a	3.87±0.06a	3.84±0.04a
T_1	3.89±0.02a	3.85±0.06a	3.83±0.24a	3.83±0.24a
T_2	3.84±0.02a	3.82±0.24a	3.79±0.4a	3.77±0.04a
T_3	3.74±0.02a	3.65±0.01a	3.51±0.04b	3.35±0.27c
Protein contents				
T_o	3.18±0.03	3.18±0.03	3.17±0.02	3.16±0.02
T_1	3.18±0.03	3.17±0.003	3.17±0.02	3.15±0.01
T_2	3.17±0.02	3.16±0.02	3.15±0.01	3.14±0.01
T_3	3.18±0.03	3.16±0.02	3.14±0.01	3.12±0.009
Lactose contents				
T_o	4.33±0.03	4.31±0.03	4.27±0.02	4.24±0.02
T_1	4.33±0.03	4.30±0.03	4.26±0.02	4.21±0.02
T_2	4.32±0.03	4.27±0.02	4.24±0.02	4.22±0.02
T_3	4.33±0.03	4.29±0.02	4.25±0.02	4.25±0.02
Ash contents				
T_o	0.66±0.02	0.65±0.01	0.65±0.01	0.64±0.05
T_1	0.66±0.02	0.66±0.02	0.65±0.01	0.64±0.05
T_2	0.66±0.02	0.65±0.01	0.64±0.05	0.64±0.05
T_3	0.66±0.02	0.65±0.01	0.65±0.01	0.64±0.05

Within rows & columns means denoted by different letters are different. T_o: Control; T_1: Pasteurized milk stored in 300 l× fluorescent light; T_2: Pasteurized milk stored in 600 l× fluorescent light; T_3: Pasteurized milk stored in 900 l× fluorescent light; All the figures present in Table 1 are statistically non-significant.

Table 2. Anisidine, conjugated dienes, peroxide value and iodine value of pasteurized milk in polyethylene pouch packs exposed to different intensities

Treatments	0-Day	2-Day	4-Day	6-Days
Anisidine value				
T_o	3.76±0.04efg	4.71±0.41cdef	5.76±0.64bc	5.88±0.25g
T_1	3.76±0.04efg	6.37±0.33b	8.22±0.05a	7.62±0.50a
T_2	3.76±0.04efg	5.47±0.56bcd	7.62±0.04g	7.68±0.37fg
T_3	3.76±0.04efg	6.35±0.83def	8.41±0.14a	8.71±0.02a
Conjugated dienes value				
T_o	0.24±0.02i	0.13±0.01i	0.23±0.008i	0.27±0.40a
T_1	0.24±0.02i	0.21±0.06i	0.64±0.03h	0.85±0.01gh
T_2	0.24±0.02i	1.09±0.04efg	1.28±0.01de	1.21±0.008ef
T_3	0.24±0.02i	1.58±0.03cd	1.81±0.03bc	1.99±0.008ab
Peroxide value				
T_o	0.18±0.02f	0.25±0.03e	0.30±0.05e	0.37±0.05e
T_1	0.20±0.02f	0.27±0.03e	0.45±0.06d	0.52±0.07d
T_2	0.17±0.02f	0.30±0.03e	0.67±0.08c	1.34±0.01b
T_3	0.22±0.02f	0.35±0.05e	0.79±0.09c	1.92±0.15a
Iodine value				
T_o	33.10±0.20a	32.56±0.14b	32.43±0.23b	31.40±0.05b
T_1	33.10±0.20a	30.46±0.14c	30.20±0.05c	29.43±0.12c
T_2	33.10±0.20a	30.20±0.12c	29.53±0.17c	28.96±0.08d
T_3	33.10±0.20a	28.23±0.12d	27.53±0.14e	26.96±0.14f

Within rows & columns means denoted by different letters are different; T_o : Control; T_1: Pasteurized milk stored in 300 l× fluorescent light; T_2: Pasteurized milk stored in 600 l× fluorescent light; T_3: Pasteurized milk stored in 900 l× fluorescent light.

have any significant effect on protein content of fresh milk (Table 1). Non-significant changes in lactose and ash content were observed when pasteurized milk was exposed to different light intensities (Table 1).

Anisidine value. Anisidine value of all the experimental samples increased during 6 days of storage period (Table 2). The increase in anisidine value depends upon intensity of light, storage time and the type of packaging material. Storage time and packaging material was same for all the treatments. The rise in anisidine value during the storage period of 9 days was in the order of $T_3 > T_2 > T_1 > T_0$.

Conjugated dienes. Conjugated dienes of all the samples increased during the storage period of 9 days (Table 2). Moyssiadi *et al*. (2004) reported an increase in conjugated dienes value when the milk was exposed to different light intensities in PET containers; however, little is known regarding the photo-oxidative stability of milk in polyethylene pouch packs. With the progression of storage period in photo-oxidation conditions, sensory score deteriorated. The rise of conjugated dienes at all the determination frequencies were in the order of $T_3 > T_2 > T_1 > T_0$.

Peroxide value. Peroxide value of all the samples increased throughout the storage period of 9 days (Table 2). The rise in peroxide value during the storage period was due to the photo-oxidation. The peroxide value increased as a function of light intensity, the effect of treatments, storage and their interaction was also significant. Peroxide value also had a great effect on the sensory characteristics of milk. The strong correlation between peroxide value and sensory score has been reported by Shiota *et al*. (2004) when ice cream was exposed to light, the length of exposure was directly related to the peroxide value.

Iodine value. Milk fat is composed of higher concentration of saturated fatty acids and lower extent of unsaturated fatty acids. Iodine value of all the treatments and control decreased during storage period of 9 days (Table 2). Iodine value of stored fats and oils is lower than the fresh stuffs (Anwar *et al*., 2010). Chatha *et al*. (2011) and Gulla and Wagahary (2011) also recorded

a similar fashion of decline in iodine value when canola oil was stored at ambient temperature for longer period of time.

Flavour score. Light exposure had a great effect on flavour score of pasteurized milk, changes in flavour score was dependent upon the intensity of light and storage period, both the factors had a great effect on flavour score of pasteurized milk (Table 3).

Table 3. Oxidized flavour score of pasteurized milk in polyethylene pouch packs exposed to different intensities

Treatments	0-Day	2-Day	4-Day	6-Days
T_o	8.2±0.26a	8.2±0.21a	7.5±0.15c	6.8±0.31d
T_1	8.2±0.26a	7.8±0.14b	7.0±0.16d	6.6±0.08e
T_2	8.2±0.26a	7.4±0.11d	6.9±0.13d	6.1±0.17g
T_3	8.2±0.26a	7.1±0.19d	6.4±0.24f	5.5±0.09h

Within rows & columns means denoted by different letters are different.

The correlation between the flavour score and light intensity was linear (R^2= 0.952). The decline in flavour score of treatments and control was in the order of $T_3 > T_2 > T_1 > T_0$. The strong correlation between light intensity and flavour score of ice cream has already been established (Shiota *et al*., 2004). The deterioration in flavour score was caused by the photo-oxidation of milk i.e., higher peroxide value yielded lower flavour score.

Conclusion

The results showed that exposure of pasteurized milk packed in polyethylene pouches at 4 °C had no effect on compositional attributes except fat content, which decreased as a function of photo-oxidation. Experimental samples exposed to 600 and 800 l× light yielded the higher extents of oxidation products, as compared to 400 l× light. Milk exposed to 400 l× light florescent light, for 6 days in three layered polyethylene pouch did not develop oxidised flavour.

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