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Research Article

Influence of Different Light Sources, Illumination Intensities and Storage Times on the Vitamin C Content in Pasteurized Milk

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Abstract: The effect of various light sources and illumination intensities on the destruction of vitamin C was determined during the storage of pasteurized milk. For this purpose, raw cow's milk was pasteurized at 72 °C for 15 s, and then stored in 2 different refrigerators (4 ± 1°C) illuminated by fluorescent and tungsten light (normal light) sources with intensities of 1100, 2400 and 5800 lux. As a control group, a pasteurized milk sample was stored at the same temperature under dark conditions. The amount of vitamin C in the milk samples was recorded after 0, 6, 12, 24, 48, 72, 96 and 120 h of storage. Vitamin C contents of the milk samples stored without a light source were higher than those of milk samples stored under the fluorescent and normal lights. As the intensity of light increased, a concomitant loss of vitamin C was observed. Conversely, as storage time increased, the content of vitamin C in the pasteurized milk samples decreased.

Key Words: Pasteurized milk, vitamin loss, vitamin C, storage time

Pastörize Sütün C Vitamini İçeriğine Farklı Işık Kaynağı, Işık Şiddeti ve Depolama Süresinin Etkisi

Özet: Bu araştırmada, pastörize sütün muhafazası sırasında C vitamininin kaybı üzerine farklı ışık kaynağı ve ışık şiddetinin etkisi belirlenmiştir. Bu amaçla inek sütü 72 °C'de 15 saniye pastörize edildikten sonra 1100, 2400, 5800 lüks şiddetindeki floresan ve tungsten lamba (normal ışık) ile ışıklandırılan 2 farklı buzdolabında (4 ± 1°C) depolanmıştır. Kontrol grup pastörize süt ise aynı sıcaklıkta karanlık şartlarda muhafaza edilmiştir. Süt örneklerinin C vitaminleri içeriği depolamanın 0, 6, 12, 24, 48, 72, 96 ve 120. saatlerinde saptanmıştır. Kontrol grubu örneklerin C vitamini miktarı floresan ve normal ışıkta depolanan süt örneklerinden daha yüksek bulunmuştur. Floresan ışıkta depolanan süt örneklerinin C vitamini miktarı normal ışıkta depolanan sütünkinden daha az bulunmuştur. Işık şiddeti arttıkça pastörize sütün C vitamini kaybı artmış ve depolama süresi uzadıkça C vitamini miktarı azalmıştır.

Anahtar Sözcükler: Pastörize süt, vitamin kaybı, C vitamini, depolama süresi

Introduction

Vitamin C is a water soluble vitamin that can be synthesized by many animals, but not by humans. Therefore, vitamin C should be consumed every day. It is sensitive to heat and light and it is destroyed over time when exposed to atmospheric oxygen (1-5). Vitamin C promotes healthy teeth and gums, helps in the absorption of iron, aids in the maintenance of normal connective tissue, and promotes wound healing. It also helps the body's immune system (1,3,4). Evidence that the antioxidant nutrients may play a much more important role in our health and well being is growing rapidly (6). Vitamin C is well known as an outstanding antioxidant in animal tissues, which means that it is quenches free radicals that can damage organs, tissues and cells (2,7).

The amount of vitamin C found in milk is 2.4 mg per 100 g (2,8). One liter of milk provides 30% of the daily vitamin C requirement. Vitamin C is sensitive to light (2,4). The presence of ascorbic acid delays the decomposition of vitamin B_2 (9). If protected from light, milk can be stored safely for long periods of time (10). Exposure of milk to sunlight or fluorescent light does not only affect the flavor quality, but also decreases the nutritional value (11).

Milk is not rich in vitamin C, but it is used as an indicator because of its sensitivity to light, which is the greatest among the other milk components (4). Furthermore, the vitamin B_2 content of milk, which is the richest among the other vitamins, is influenced by light. Therefore, the sensitivity of vitamin C to light is also regarded as an indicator for vitamin B_2 (4,12).

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Singh et al. (13) reported that vitamins B_2 and C are responsible for a rancid flavor in milk. Destruction of vitamin B_2 also accelerates the deterioration of vitamins A and C (14). Deger and Ashoor (15) reported that when milk was exposed to sunlight, especially at wavelengths of 415-455 nm, which are emitted by fluorescent bulbs (11), the light causes vitamin loss and aroma defects.

The purpose of this study was to determine the effects of various light sources and light intensities on the destruction of vitamin C in pasteurized milk during various storage times. The determination of the conditions to minimize the vitamin C loss until the consumption of milk was also considered.

Materials and Methods

Materials

Raw cow's milk, obtained from the Agriculture Management Department, the Faculty of Agriculture, Atatürk University, was adjusted to 3% fat content and then pasteurized at 72 ºC for 15 s. The pasteurized milk was transferred into presterilized glass jars in 500 ml aliquots and stored in 2 different refrigerators (4 ± 1 ºC) with tungsten (9, 15, 23 W lamps, normal light) and fluorescent light (60, 75, 100 W lamps). The milk samples of the control group were wrapped in aluminum foil and stored in the same refrigerators. At each time period one bottle from each group was analyzed.

The experiment was designed with 2 light sources (fluorescent and normal lamps) x 3 light intensities (1100, 2400, 5800 lux) x 8 storage times (0, 6, 12, 24, 48, 72, 96, 120 h) with 6 replications.

Methods

Pasteurized milk was analyzed with a phosphate test using a Lactognost tablet (Heyl, Berlin, Germany). Total vitamin C was measured as described by Cemeroğlu (16), by titrating the filtrate after metaphosphoric acid treatment of the milk, with 2, 6-dichlorophenol-indophenol.

Light intensity was measured with a digital Sper Scientific light meter.

The data were analyzed using ANOVA. Significant means were further analyzed with Duncan's multiple range tests. The significant interactions were also displayed in the appropriate figures (17).

Results

The effect of different light sources on the vitamin C level in pasteurized milk was significant ($P < 0.01$). The milk samples stored under normal light contained more vitamin C than those stored under fluorescent light (Table 1). The light intensity affected the amount of vitamin C at a statistically significant level ($P < 0.01$). According to results of Duncan's multiple range test (Table 2), the maximum vitamin C was in the milk stored without a light source. The effect of light source x light intensity on total vitamin C content was statistically significant ($P < 0.01$) (Figure 1). The storage time affected the vitamin C contents of pasteurized milk samples significantly ($P < 0.01$). Vitamin C concentrations in pasteurized milk samples decreased during storage. The effect of the light intensity x storage time interaction on vitamin C was statistically significantly ($P < 0.01$). Vitamin C content in all samples decreased gradually during storage (Figure 2).

Discussion

The milk samples stored under normal light contained more vitamin C than those stored under fluorescent light (Table 1). According to the results of Duncan's multiple range test, the maximum vitamin C was in the milk stored

Table 1. Vitamin C contents of the pasteurized milk stored under tungsten and fluorescent light sources*.

Light source	Vitamin C (mg/l)
Fluorescent lamp	8.79 a
Tungsten lamp	9.26 b

* Means in a column with different letters are significant ($P < 0.01$).

Table 2 Vitamin C contents of the pasteurized milk stored under different light intensities*.

Light intensities (lux)	Vitamin C (mg/l)
Control (dark)	12.93 a
1100	8.38 b
2400	7.70 c
5800	7.09 d

* Means in a column with different letters are significant ($P < 0.01$).

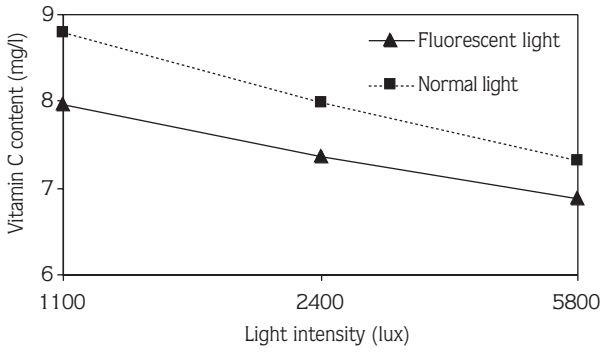

Figure 1. Vitamin C content in relation to light source and light intensity.

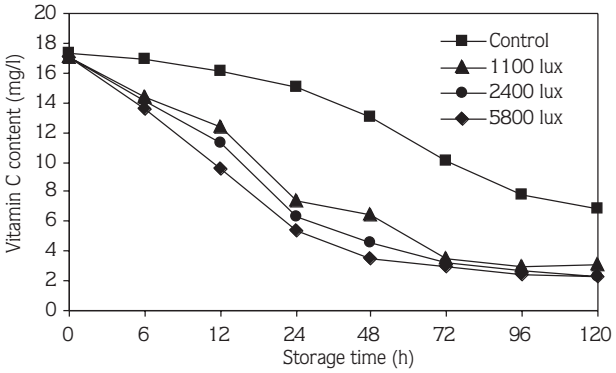

Figure 2. Changes in vitamin C content in relation to light intensity and storage time.

under dark conditions (control group) (Table 2). The maximum vitamin C content was measured in the milk samples stored under 1100 lux normal light, while the minimum content was in the milk samples stored under 5800 lux fluorescent light. As the light intensity increased, a concomitant loss in vitamin C was observed (Figure 1). It has been recommended that the packaging materials used for milk should not transmit light, which accelerates chemical reactions. Schröder et al. (14) reported that vitamin loss in pasteurized milk stored under fluorescent light in carton boxes was similar to that stored without a light source. Vitamin C concentrations in pasteurized milk samples decreased during storage because the vitamin C content of food is strongly influenced by the length of storage (18). According to Duncan's multiple range test (Table 3), maximum vitamin C concentrations were found immediately after the pasteurization process, while the minimum concentration was determined at the last stage of storage (120 h). The vitamin C contents determined in each stage of storage were statistically different. There are numerous reports in the literature about the instability of vitamin C during storage (19,20). Scott et al. (9) reported that 25% of the vitamin C content found in milk was reduced during the milking, bottling and heating processes. They also reported that vitamin C was converted into diketogulonic acid, an inactive compound, when pasteurized milk was stored under light. The authors also noted that a substantial amount of the vitamin C content of pasteurized milk was destroyed within the first storage period (1 h) under sunlight, and as the cooling time extended the loss continued (9). Vitamin C content in all samples decreased gradually during storage. The amounts of vitamin C stored under normal and fluorescent lights of

Table 3. Vitamin C contents of the pasteurized milk at different storage times*.

Storage time (hour)	Vitamin C (mg/l)
Initial	17.08 a
6	14.82 b
12	12.82 c
24	9.05 d
48	7.02 e
72	5.26 f
96	4.14 g
120	3.86 h

* Means in a column with different letters are significant ($P < 0.01$).

differing intensities decreased dramatically within the first 24 h and gradually within 24-72 h. However, vitamin C concentrations were almost stable during 72-120 h (Figure 2). This trend may be due to chemical reactions and/or the oxygen content of the milk. The vitamin C content of milk stored under 1100 lux was slightly higher than that of milk stored under 2400 lux and 5800 lux. In the further stages of storage, there were no differences among the samples, although the vitamin contents of the samples were lower than those of the control group (Figure 2).

The analysis and evaluation of the results of the experiment showed that pasteurized milk should be delivered in light-proof packaging materials and stored in refrigerated conditions immediately following production to prevent the destruction of vitamin C. When delivered in transparent glass bottles, milk should not be stored under light over 1100 lux intensity. Furthermore, tungsten lamp illumination should be preferred to fluorescent light.

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