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Effect of ultraviolet light on water- and fat-soluble vitamins in cow and goat milk

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ABSTRACT

The objective of this study was to investigate and compare the effects of UV light and heat treatment on vitamins A, B_2, C, and E in cow and goat milk. Vitamins were analyzed by reverse-phase high-pressure liquid chromatography. Ultraviolet and pasteurization treatments caused loss in vitamin C in milk. Pasteurization did not have any significant effect on vitamin B_2. However, UV light treatment decreased the amount of vitamin B_2 after several passes of milk through the UV system. In addition, UV light treatment decreased the amount of vitamins A and E. Vitamins C and E are more sensitive to UV light. UV light sensitivities of vitamins were $C > E > A > B_2$. These results show that UV light treatment decreases the vitamin content in milk. Also, the number of passes through the UV system and the initial amount of vitamins in milk are important factors affecting vitamin levels.
Key words: ultraviolet light, fat- and water-soluble vitamins, cow milk, goat milk

INTRODUCTION

For the production of milk and dairy products, heat treatment is the most common process to inhibit the growth of pathogens and spoilage microorganisms and to inactivate enzymes in milk. Three types of heat treatment to milk include thermization, pasteurization, and sterilization in the dairy industry (Raynal-Ljutovac et al., 2007). Pasteurization is widely used as a thermal process for milk. In pasteurization, milk is heated to 63°C for 30 min (low temperature, long time) or to 72°C for 15 s (HTST; Fox and McSweeney, 1998). Physical, chemical, and sensorial changes may occur during heat treatment of milk. Although some changes are favorable, others are considered undesirable, because they cause adverse effects on sensory characteristics, nutritional values, and technological properties of milk (Fox and McSweeney, 1998; Lewis, 2003).

A loss of water- and fat-soluble vitamins in milk during the heating process has been reported (Holmes et al., 1945; Lavigne et al., 1989; Oamen et al., 1989; Sierra and Vidal-Valverde, 2001; Bendicho et al., 2002; Asadullah et al., 2010; Moltó-Puigmartí et al., 2011). Holmes et al. (1945) reported that HTST pasteurization (71–83°C, 22 s) of raw milk results in 18.7 and 3% of losses of vitamin C and B_1 (thiamin), respectively. No change to vitamin B_2 (riboflavin) content was observed. Lavigne et al. (1989) evaluated different pasteurization and sterilization processes in terms of changes to vitamins B_1, B_2, and C content in goat milk. Low-temperature, long-time (**LTLT**; 63.5°C for 30 min), HTST (76°C for 16 s), UHT (135°C for 4 s), and sterilization (121°C for 15 min) decreased the vitamin C level in goat milk at the rate of 40, 25, 30, and 70%, respectively. No significant decrease in vitamin B_2 content by HTST and UHT processing was observed. However, LTLT and sterilization decreased vitamin B_2 content by 20 and 30%, respectively. Asadullah et al. (2010) reported that household heating of milk (boiling about 100°C for 15 min) causes 27, 27, 29, 24, and 36.2% loss in vitamins B_1, B_2, B_3, B_6, and folic acid, respectively. Moltó-Puigmartí et al. (2011) investigated effects of LTLT pasteurization and high-pressure processing on ascorbic acid (vitamin C) and α- and δ-tocopherol isomers (vitamin E) in human milk. Low-temperature, long-time processing reduced vitamin C and α- and δ-tocopherol isomers in human milk at rates of 16.2, 0.97, and 2.08%, respectively. High-pressure processing did not significantly affect ascorbic acid and tocopherol levels.

Today, increasing consumer preference for high nutritional and quality food products have led to the development of novel techniques to process dairy products. Ultraviolet light treatment has commercial potential among nonthermal food technologies as an alternative to heat treatment (pasteurization) of liquid foods (Bintsis et al., 2000; Lopez-Malo and Palou, 2005; Koutchma, 2009). Ultraviolet light has been used for

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disinfection of surfaces, air, water, and equipment for over 60 yr. The UV light spectrum ranges from 100 to 400 nm. The range of 200 to 280 nm UV light spectrum (UV-C) has a germicidal effect on microorganisms, including bacteria, yeasts, molds, and viruses. Microbial inactivation in liquid foods by UV-C depends on optical and flow properties of the product, microbial load of the product, geometric configuration of the reactor, power, wavelength and physical arrangement of the UV source(s), and radiation path length (Koutchma et al., 2009). These critical factors of UV treatments for liquid food processing are discussed by Koutchma et al. (2009).

Several studies have been conducted on determining the effects of UV treatment on microbiological, physicochemical and sensory properties of clear liquid foods, such as fruit juices (Gachovska et al., 2008; Keyser et al., 2008; Franz et al., 2009; Guerrero-Beltrán et al., 2009; Fredericks et al., 2011; Uysal Pala and Kırca Toklucu, 2011; Caminiti et al., 2012). However, only a limited number of studies have been done on UV light applications in opaque liquid foods such as milk and liquid dairy products. Although UV light influence on pathogens and indicator microorganisms in milk has been a particular focus in these studies (Smith et al., 2002; Matak et al., 2005; Reinemann et al., 2006; Altic et al., 2007; Donaghy et al., 2009; Engin et al., 2009), its effects on nutritional properties of milk have not been assessed. Therefore, the aims of this research were to determine the effects of UV light and pasteurization on vitamins C, B_2, A, and E and to compare the vitamin losses by pasteurization and UV light treatment in milk from cows and goats.

MATERIALS AND METHODS

Milk

Goat milk samples (n = 3) were obtained from the Turkish Saanen breed in the late-lactation period (October 2010 to April 2011) at Canakkale Onsekiz Mart University-Technological and Agricultural Research Center (Canakkale, Turkey). Cow milk samples (n = 4) were obtained from local producers (May–July 2011) in Canakkale. One of the cow milk samples (C4) was used for the manipulation experiment. Milk samples were carried in thermo bag with an ice pack at 10°C and analyzed immediately in our laboratory.

Pasteurization

Milk samples were pasteurized in a 1-L glass jar in a thermostatic water bath [Gesellschaft für Labortechnik (GFL) mbH, Großburgwedel, Germany] at 65°C for 30 min.

UV Light Treatment

A custom-made UV light system equipped with 9 UV-C type lamps (Gentra Stock Joint Co., Istanbul, Turkey) was used for UV treatment of milk (Engin and Karagul Yuceer, 2012). The UV reactor was designed by Yusuf Köprülü (Gentra Insaat ve Ticaret Ltd. Sti., Istanbul, Turkey). The UV unit consists of a stainless steel reflector, a corrugated Teflon tube coiled around quartz sleeve and 9 UV lamps (254 nm; 28 W UV-C output; the length of each lamp was 842.4 mm and the diameter was 16 mm). The UV light intensity per single pass through the reactor was calculated based on the flow rate of milk through the reactor and total output wattage of UV lamps (Engin and Karagul Yuceer, 2012) by using Equation 1, suggested by Geveke (2008) and Keyser et al. (2008):

$$\text{UV intensity (J/mL)} = \text{total UV-C output power (W)/flow rate (mL/s)}. \quad [1]$$

Seven passes were applied to milk in the reactor to evaluate changes to vitamin content under UV light. Vitamin analysis was conducted after 1, 3, 5, and 7 passes. The beginning temperature of the milk was 18°C and was raised to 25°C after 7 passes through the system. The UV light intensities applied to milk samples are shown in Table 1.

Composition of Milk

The titratable acidity (lactic acid, %), pH, and DM (%), total protein (%), and ash (%) contents of the milk samples were determined according to procedures described by Bradley et al. (1992). The fat content of the milk samples was determined using a method by Gerber-Van Gulik (NEN, 1969).

Table 1. Ultraviolet light intensity applied to cow and goat milk

	UV intensity (J/mL of milk)	
UV treatment	Cow milk	Goat milk
First pass	12.6	11.72
Third pass	37.8	35.16
Fifth pass	63.0	58.60
Seventh pass	88.2	82.04