Food Chemistry 125 (2011) 307–317

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

The effects of silage feeding on some sensory and health attributes of cow's milk: A review

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ARTICLE INFO

Article history:
Received 4 March 2010
Received in revised form 18 June 2010
Accepted 23 August 2010

Keywords:
Silage
Bovine milk
Carry-over
Review
Vitamins
Volatile compounds
Terpenes
Carotenoids
Estrogens
Mycotoxins
Bacillus cereus
Clostridium tyrobutyricum
Listeria monocytogenes

ABSTRACT

Silage has been the prevailing type of preserved forage for cattle feeding in many countries. Carry-over of some components from silage to cow's milk has been thus of concern. Silage is a richer source of available provitamins A, other carotenoids and tocopherols than hay due to higher losses of these compounds during forage field-drying and hay storage. Ensiled grasses and legume forages contain higher levels of carotenoids and tocopherols than maize silage. Numerous terpenes are carried-over to milk and cheeses from grazed multifloral pastures or from hay, while silages are a poorer source of these flavour-affecting compounds. Data on alcohols, acids, esters, aldehydes and ketones in silage and especially information on their carry-over to milk are insufficient. Milk can gain a bad smell from a stable atmosphere if silage, particularly of poor quality, is fed. Red clover silage feeding can cause considerable levels of estrogenic equol in milk. Deoxynivalenol and zearalenone are the main mycotoxins formed in silage. Their content is reduced by the activity of both some lactic acid bacteria in silage and rumen microflora. The excretion of the mycotoxins in milk is generally low. Silages can be a pool of the undesirable bacteria *Bacillus cereus*, *Clostridium tyrobutyricum* and *Listeria monocytogenes*. Milk contamination with these bacteria can be decreased by the prevention of silage deacidification following air access, and by improving the dairy farm environment, cow hygiene and by sanitary milk harvesting.

Contents

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doi:10.1016/j.foodchem.2010.08.077

1. Introduction

Consumers have perceived differences in the sensory properties of milk, butter and cheeses, such as flavour, taste, colour and texture. Such dissimilarities have been observed not only among milks and products of different origin but also within individual products. Consumers commonly prefer "green image" products originating from dairy cows grazing natural swards of varied botanical composition to those from winter feeding with preserved forages. Among such forages, hay has been commonly accepted as superior to silage. Nevertheless, feeding of silage considerabely exceeded hay in many countries with cold and wet weather complicating the production of high quality hay. Grasses, maize (*Zea mays*), lucerne (*Medicago sativa*) and red clover (*Trifolium pratense*) have been the main ensiled forages in temperate areas. Various feeding managements have been used, from dairy cows grazed for many months in countries with mild climate, to year-round rations of in-housed cows based on silage and concentrates.

The main principles of preservation by ensilage are the rapid achievement of anaerobic conditions and the low pH value. Technological operations support the domination of lactic acid bacteria in their competition with other microoganisms for the available nutrients, mainly water-soluble carbohydrates. Production of lactic acid and to a lesser extent of acetic acid increases the acidity of ensiled forage and suppresses the risk of undesirable types of fermentation. The biochemistry and microbiology of silage was described in depth by McDonald, Henderson, and Heron (1991).

The effects of various forages feeding on milk composition have been studied for decades. The substantial interest has been focused on milk fat composition. Altering the fatty acid composition has both long-term effects on the health of consumers and technological aspects (e.g. firmness and susceptibility to rancidity). The composition of feeding rations has been an important factor enabling the control of the milk fat composition. Such broad topic is out of scope of this article. An overview is available from the reviews of Dewhurst, Shingfield, Lee, and Scollan (2006), and Elgersma, Tamminga, and Ellen (2006).

The aim of this review is to collect and evaluate the information on the less frequently studied effects of various silages feeding on some sensory and health attributes of cow's milk and cheeses. More specifically, the recent knowledge on the transfer of vitamins, various volatile compounds, carotenoids, estrogens, mycotoxins, and some detrimental bacteria, from silage to milk, will be reviewed.

2. Vitamins

2.1. Fat-soluble vitamins

Cow's milk is recognised as an important source of fat-soluble vitamins, especially retinol (vitamin A_1) and tocopherols (vitamin E) in the human diet. Their contents in milk are affected by several factors, such as nutrition, season, dairy cow management, genetics and stage of lactation.

The effect of season was demonstrated in French farm tank (bulk) milk by Agabriel et al. (2007). They reported a mean retinol concentration of 7.2–7.6 and 5.2 mg kg^{-1} of milk fat between May and September, and in March, respectively. The respective α-tocopherol mean levels were 18.8–21.7 and 10.5 mg kg^{-1} of milk fat. The differences in the α-tocopherol concentration were attributed to the proportion of grazed grass or grass silage in the forage. During another year-round study comparing milks from the UK farms, Ellis et al. (2007) determined mean retinol concentrations of 16.3 ± 3.7 and 14.1 ± 2.6 mg kg^{-1} milk fat for conventional and organic farms, respectively. The respective α-tocopherol levels were 43.2 ± 9.9 and 41.0 ± 9.9 mg kg^{-1} milk fat. The differences were significant for retinol only. The higher level in milk from the conventional farms is probably caused by the increased vitamin A supplementation in the concentrates. The lowest contents of both vitamins were observed during the winter period. The seasonal changes were similar in both farming systems.

Both the retinol and tocopherols concentrations in tank milk were comparable in the three management systems that were compared during a year-round study: feeding with silages year-round; grazing during summer season under conventional farming conditions, and grazing during summer season under organic farming conditions (Jahreis, Schneider, Böhm, & Bitsch, 1997).

Both the retinol and tocopherols losses are higher in hay than in silage. Shingfield et al. (2005) reported concentrations of 53.8–67.8 and 10.8–19.6 mg kg^{-1} dry matter of α-tocopherol and γ-tocopherol, respectively, in silages prepared from pre-wilted timothy (*Phleum pratense*) and meadow fescue (*Festuca pratense*) mixture. The respective concentrations in hay prepared from the same sward were 22.3 and 9.4 mg kg^{-1} dry matter. The α-tocopherol concentrations were 1.10–1.15 and 0.54 mg kg^{-1} milk from cows fed silages or hay. The respective retinol concentrations in milk were 0.24–0.33 and 0.26 mg kg^{-1}. The secretion of α-tocopherol in milk was related to the dietary intake and it was transferred into milk with a mean efficiency of 2.8%. Thus, the effects of diet on the milk α-tocopherol contents reflected more extensive losses during the field drying than during the ensiling of grass under anaerobic conditions.

The grass-red clover silage showed to be a richer source of available tocopherols than maize silage. The concentrations of α-tocopherol were 0.85 and 0.38 mg l^{-1} and those of γ-tocopherol 0.03 and 0.01 mg l^{-1} in the milk of dairy cows fed grass-clover silage or maize silage, respectively (Havemose, Weisbjerg, Bredie, & Nielsen, 2004). More rapid losses of α-tocopherol and formation of oxidative products were observed in milk from dairy cows fed diets based on red clover or lucerne silages than from those fed grass silage. The increased oxidative deterioration of milk from cows fed red clover silage was avoided by vitamin E supplementation (Al-Mabruk, Beck, & Dewhurst, 2004).

A shift from grass silage to hay diet caused a rapid decrease in the α-tocopherol concentration in milk during the initial 2 weeks. Then, the concentrations slightly increased and remained stable for further 6 weeks. At the end of the experiment, the concentrations were 21.4 and 14.2 mg kg^{-1} of fat following grass silage and hay feeding, respectively, under the conditions of high energy intake, while the respective values were 26.2 and 17.4 mg kg^{-1} of fat under energetic underfeeding. The corresponding retinol concentrations were 4.08 and 2.97 mg kg^{-1} of fat at high energy intake, and 5.48 and 4.17 mg kg^{-1} of fat at low energy intake (Nozière et al., 2006b).

An inverse shift from hay diet to diets with increasing proportion of grass silage and lucerne protein concentrate as sources of the α-tocopherol and β-carotene was investigated by Calderón