Animal Feed Science and Technology xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Influence of fish oil alone or in combination with hydrogenated palm oil on sensory characteristics and fatty acid composition of bovine cheese

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ARTICLE INFO

Article history:
Received 30 December 2014
Received in revised form 14 April 2015
Accepted 15 April 2015
Available online xxx

Keywords:
Cheese
Fatty acids
Fish oil
Milk

ABSTRACT

The objective of the present study was to evaluate the effect of dietary supplementation of fish oil (FO) alone or in combination with hydrogenated palm oil (FOPO) on the fatty acid (FA) profile of milk and cheese from dairy cows, and the sensory characteristics of cheese. Nine Holstein cows (173 ± 21 DIM) were used in a replicated 3 × 3 Latin square design with three 21 d periods. Except for milk lactose yield, milk and cheese components were not affected by dietary treatment. Cheese elaborated from milk when cows were supplemented with FO had a more intense yellowness and higher notes for colour homogeneity than cheese elaborated from milk when cows were on control and FOPO treatments. FOPO treatment resulted in cheese with higher tough texture than control and FO treatments. Milk and cheese contents of C6:0, C8:0, C10:0 and C14:0 and atherogenicity index were lower with FO and FOPO treatments than with control. Compared with control and FOPO, FO treatment increased VA and DHA content in milk and cheese. In conclusion, supplementation of dairy cow diets with FO alone or in combination with hydrogenated palm oil can enhance the FA profile of milk and cheese without deleterious effects on sensory characteristics of cheese.

1. Introduction

Addition of lipid supplements to dairy cow diets has been shown to affect milk and cheese fatty acid (FA) composition. Vaccenic (VA; C18:1 t11) and rumenic (RA; C18:2 c9, t11) acids could be beneficial from a human health standpoint (Lock and Bauman, 2004). Also, it has been shown that eicosapentanoic (EPA; C20:5n3) and docosahexaenoic (DHA; C22:6n3) acids play an important role in preventing cardiovascular and autoimmune diseases (Astarita et al., 2014). The most rapid and practical way to increase those FA in milk or dairy products is by modifying diets of dairy cows. Inclusion of fish oil (FO) in diets for high-producing dairy cows can increase VA, RA (AbuGhazaleh and Holmes, 2007) and DHA (Allred et al., 2006) in milk. Hydrogenated palm oil (PO) can be used as a supplement in dairy cow diets, maintaining or improving lactation performance with minimal interference on ruminal fermentation (Kargar et al., 2012).

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http://dx.doi.org/10.1016/j.anifeedsci.2015.04.013
0377-8401/

Although some studies (Lynch et al., 2005; Jones et al., 2005; Allred et al., 2006) have reported effects of FO on acceptability of milk or dairy products, there is no report on effects of FO or a blend of FO + PO on Chanco cheese. Chanco cheese (a yellowish creamy and semisoft cheese) is one of the most important cheeses in Chile (Vargas-Bello-Pérez et al., 2014). The objective of the present study was to test the hypothesis that the FA profile of milk and Chanco cheese can be improved by supplementing cows with FO as a polyunsaturated FA (PUFA) source or FO + PO as a blend of PUFA and saturated FA (SFA) sources without compromising sensory characteristics of cheese that are acceptable for consumers.

2. Materials and methods

2.1. Animals and treatments

The study was conducted at the Estación Experimental Pirque of the Pontificia Universidad Católica de Chile. Nine multiparous Holstein cows (173 ± 21 DIM) were used in a replicated 3 × 3 Latin square design with three cows fed on each of three treatments in three 21 d periods. At the beginning of the study mean body weight (BW) of cows was 621.4 ± 94.8 kg and mean body condition score (BSC) was 3.4 ± 0.4 (Scored on a five-point scale where 1 = emaciated to 5 = overly fat; Wildman et al., 1982). Body weight and BCS were recorded at the end of each experimental period. Cows were offered a total mixed ration once daily (09:30 h). All cows received a basal diet containing 56% forage and 44% concentrate to satisfy requirements of cows producing 30 L of milk per day (NRC, 2001). Dietary treatments consisted of a basal diet (Control; no fat supplement), and fat-supplemented diets containing fish oil (FO; manufactured from salmon oil; 500 g/d/cow) and FO (250 g/d/cow) + hydrogenated palm oil (PO; manufactured from palm oil; 250 g/d/cow). Fish oil contained (g FA/100 g total FA) 8 of C14:0, 17 of C16:0, 8 of C17:0, 4 of C18:1n11t, 19 of C18:1n9c, 3 of C18:2n6c, 2 of C20:4n6, 2 of C22:2, 20 of C20:5n3 and 17 of C22:6n3, whereas hydrogenated palm oil contained 2 of C10:0, 14 of C12:0, 7 of C14:0, 44 of C16:0 and 33 of C18:0. Oils were administrated separately and mixed manually into the daily ration for each cow. Animals were housed in individual stalls (2.4 m × 6 m) and had continuous access to water. Animal care and procedures were carried out according to the guidelines of the Animal Care Committee of the Pontificia Universidad Católica de Chile.

Treatment diets were sampled every 7 days and stored at −20 °C for later chemical analyses. Standard procedures (AOAC, 2006) were used to determine the DM (934.01), Kjeldahl N (984.13), and ether extract (920.39). Neutral detergent fibre and ADF and lignin were determined by methods described by Goering and Van Soest (1970) and Van Soest et al. (1991). Chemical composition of the diets is shown in Table 1.

2.2. Milk yield and composition

Cows were milked daily at 07:00, 15:00 and 22:00 h. Milk yields were recorded daily and individual samples were taken from the morning milking on day 21 of each period. Milk production during the last 10 d of each period was used for statistical analysis to ensure there was no carryover effect from one period to the next. Milk (150 mL/cow) from each cow was preserved with potassium dichromate (300 mg) and stored at −20 °C for later analysis. Milk samples were analyzed for fat content (Gerber method; British Standards Institution 696, 1969), crude protein (16.036; Kjeldahl $N \times 6.38$), ash (AOAC 16.035) and total solids (16.032) according to AOAC (1984) procedures. Lactose was measured by the Lane-Eynon method.

2.3. Cheese manufacturing and compositional analyses

Milk collected on day 21 was pooled from 3 cows within the same treatment and period and made into cheese. Milk used for cheese elaboration was not standardized for fat content. Cheeses were made in a pilot plant as follows: 15 L of milk per treatment per period were heated to 70 °C for 10 min, and then allowed to cool to 38 °C before addition of commercial rennet to curdle the milk and addition of calcium chloride (6 g $CaCl_2$/100 mL H_2O). No starter culture was added for cheese making. After milk had clotted (45 min), the curd was cut into cubes of 2 cm and then the vat temperature was gradually increased to 37 °C at a rate of 1 °C/3 min and maintained for 15 min. The curd was stirred to remove the whey and favour grain aggregation. Curds were placed into 250 g moulds and pressed in a horizontal mechanical press. Cheeses were salted in brine at 10 °C for 12 h and then transferred to a ripening room where they remained at a temperature of 9–10 °C and ∼90% RH for 14 d.

Four cheeses per treatment per period were allowed to mature for 14 d. Two cores of each cheese were obtained for chemical composition and FA analyses. Cheeses were analyzed for moisture content by AOAC (2000) method 934.01 and for ash content by AOAC (1990) method 942.05. Fat content of cheese samples was determined using the Gerber method, and the total protein content was determined by measuring total nitrogen (976.06; $N \times 6.38$), according to AOAC (1990).

Cheese colour measurements were determined according to the CIE L*, a*, and b* LAB colour system, (CIE 1976) using a colorimeter CR-400 (Konica Minolta, Japan). Colour measurements were made as follows: 6 on different parts of the cheese surface and 6 after removing approximately 3 cm layer of the upper surface.

Please cite this article in press as: Vargas-Bello-Pérez, E., et al., Influence of fish oil alone or in combination with hydrogenated palm oil on sensory characteristics and fatty acid composition of bovine cheese. Anim. Feed Sci. Tech. (2015), http://dx.doi.org/10.1016/j.anifeedsci.2015.04.013