Animal Feed Science and Technology 193 (2014) 148–154

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Short communication

Effect of feeding phenolic compounds from propolis extracts to dairy cows on milk production, milk fatty acid composition, and the antioxidant capacity of milk

S.C. Aguiar[a,*], S.M. Cottica[b], J.S. Boeing[b], R.B. Samensari[a], G.T. Santos[a], J.V. Visentainer[b], L.M. Zeoula[a]

[a] Departamento de Zootecnia, Universidade Estadual de Maringá, Av. Colombo 5790, 87020-900 Maringá, PR, Brazil
[b] Departamento de Química, Universidade Estadual de Maringá, Av. Colombo 5790, 87020-900 Maringá, PR, Brazil

ARTICLE INFO

Article history:
Received 30 October 2013
Received in revised form 8 April 2014
Accepted 15 April 2014

Keywords:
Antioxidant activity
CLA
Dairy
Flavonoids
Milk quality
Phenolic acids

ABSTRACT

Four ruminally cannulated primiparous lactating cows were used in a 4 × 4 Latin square design experiment to evaluate the effects of propolis-based products (PBP; obtained under different concentrations of propolis and levels of alcohol) on milk production, milk fatty acid (FA) composition, and the antioxidant capacity of milk. The total mixed ration consisted of 591.9 g/kg of corn silage and 408.1 g/kg of concentrate [dry matter (DM) basis], and treatments differed with regard to the inclusion or exclusion of PBP as follows: control (CON; excipient without phenolic compounds from the propolis extract), PBP1–PBP3 (3.81, 3.27 and 1.93 mg of phenolic compounds/kg of ingested DM, respectively). Adding propolis to the diets had no effects on DM intake, milk production, feed conversion efficiency, milk solid concentrations, or somatic cell score. Milk FA composition was changed by the addition of PBP. The content of *cis*9,*trans*11-18:2 (CLA isomer) was 50.8% higher in the PBP2 than in the CON ($P < 0.001$). The PBP3 increased monounsaturated FA (MUFA) and polyunsaturated FA (PUFA) contents and reduced ($P = 0.029$) the proportion of saturated FA (SFA). Further, the addition of PBP reduced ($P < 0.001$) the *n*6:*n*3 ratio in milk fat when compared with that in the CON. The antioxidant capacity of milk increased ($P < 0.001$) with the addition of phenolic compounds from PBP in the diet. Propolis improves milk quality when added to the diet of dairy cows, but different amounts of phenolic compounds can influence the beneficial effects of PBP on dairy milk.

1. Introduction

For many years, antibiotics have been used in ruminant nutrition to improve feed efficiency and promote livestock growth; however, over the last few years, there has been an increasing interest in exploiting natural products as feed additives in animal nutrition that do not present risks to public health. Plant extracts offer a unique opportunity in this regard (Wallace, 2004), as many plants produce secondary metabolites such as saponins, tannins, and polyphenolics that

Abbreviations: PBP, propolis-based product; CAPE, caffeic acid phenethyl ester; DM, dry matter; TMR, total mixed ration; BW, body weight; NFC, non-fiber carbohydrates; SCC, somatic cell counts; FCM, fat-corrected milk; FCE, feed conversion efficiency.

* Corresponding author. Tel.: +55 4430118958; fax: +55 4432614999.
E-mail addresses: scdeaguiar@ig.com.br, silariana@hotmail.com (S.C. Aguiar).

http://dx.doi.org/10.1016/j.anifeedsci.2014.04.006
0377-8401/

Table 1
Flavonoids and phenolic acids identified in the propolis dry extracts.

	Propolis dry extract[a]		
	PBP1	PBP2	PBP3
Phenolic compounds (g/kg of propolis dry extract)			
Chlorogenic acid	nd[b]	0.31	nd
Caffeic acid	5.27	6.17	4.03
p-Coumaric acid	9.30	10.59	6.85
Benzoic acid	0.76	1.56	0.58
CAPE	3.54	3.48	1.93
Artepillin C	9.86	9.45	6.01
Apigenin	9.95	7.39	4.83
Pinocembrin	6.39	4.70	3.02
Galangin	1.93	nd	nd
Chrysin	5.07	3.44	2.09
Acacetin	5.27	4.74	2.65

[a] Extracted under different concentrations of propolis and levels of alcohol.
[b] Not detected.
Daily amount of phenolic compounds ingested by the cows: PBP1 = 3.81 mg of phenolic compounds/kg of ingested DM; PBP2 = 3.27 mg of phenolic compounds/kg of ingested DM; PBP3 = 1.93 mg of phenolic compounds/kg of ingested DM.

have antimicrobial properties. These compounds have been extensively assessed for their role in the manipulation of rumen microbial fermentation. They have also been shown to affect rumen fermentation to varying degrees depending on their source and concentration in diets (Narvaez et al., 2013). Propolis, or bee glue, is a resinous material collected by worker bees from the leaf buds of numerous plant species and enriched with salivary and enzymatic secretions (Castaldo and Capasso, 2002). Due to its biologically active compounds, propolis has numerous pharmacological properties, thus highlighting its antimicrobial and antioxidant activities (Marcucci et al., 2001; Shimizu et al., 2004). Many researchers have investigated the effects of propolis extracts on ruminant metabolism and nutrition (Prado et al., 2010; Itavo et al., 2011), but there are no data regarding the effects of propolis on milk fatty acid (FA) composition.

Milk fat content and FA composition can be significantly altered through changes in the nutritional diet of dairy cows, thus offering the opportunity to respond to market forces and human health recommendations (Lock and Shingfield, 2004). Thus, propolis may be an alternative to improve milk quality, by manipulating lipid metabolism and modifying the FA composition in milk.

Milk fat is very susceptible to oxidation, which is a major deteriorative reaction that occurs during the processing, distribution, and storage of milk and dairy products and, moreover, can cause other changes that affect the nutritional quality, integrity, and safety of milk. Propolis has strong antioxidant activities. However, it cannot be used in its raw form (Sforcin and Bankova, 2011), and some findings have shown that the antioxidant activity of propolis is directly related to the concentrations of phenolic compounds in the extracts, which are influenced by the extraction conditions (Cottica et al., 2011).

The objectives of the current experiment were to evaluate the effect of propolis-based products (PBP; obtained under different concentrations of propolis and levels of alcohol) on milk production, milk fatty acid composition, and the antioxidant capacity of milk from middle lactation dairy cows.

2. Material and methods

2.1. PBP

Propolis samples were obtained from the apiary of the Experimental Farm of Iguatemi (FEI), belonging to the Universidade Estadual de Maringá, Paraná State, Brazil. The apiary is located within a reserve of eucalyptus plants (*Eucalyptus* sp.) surrounded by native forest and the presence of alecrim-do-campo (*Baccharis dracunculifolia*). The PBP is protected by the intellectual property application under no. 0605768-3 in Brazil. The propolis extracts were obtained at a concentration of propolis ranging from 5.0 to 30.0 g diluted in 100 mL of a water–alcohol solution ranging from 60.0 to 93.8 mL of alcohol by turbo extraction, for 15 min. The extracts were filtered under vacuum, after which the alcohol was removed in a rotary evaporator (model RT 210, Büchi Laboratory Equipment, Flawil, St. Gallen, Switzerland). Subsequently, the extracts were spray dried in a nebulizer (MSD 1.0, Labmaq, Ribeirão Preto, SP, Brazil) with a capacity of 1 L/h and an inlet temperature of 100 °C. The PBP powder fed to the animals contained the dried propolis extracts and an excipient (*i.e.*, ground corn and soybean meal). The excipient was used to add volume to the propolis extract and facilitate feeding. The composition of flavonoids and phenolic acids found in the propolis dry extracts is shown in Table 1. The PBP differ in both composition and amount of phenolic compounds resulting in three unique products. Quantification of these compounds was performed using high-performance liquid chromatography with a photodiode array detector (Alliance HPLC-PDA, Waters Co., Milford, MA, USA).