J. Dairy Sci. 101:1–9
https://doi.org/10.3168/jds.2018-14439

Effects of phytonutrients alone or in combination with monensin on productivity in lactating dairy cows

J. Oh,* M. Harper,* C. H. Lang,† E. H. Wall,‡ and A. N. Hristov*[1]
*Department of Animal Science, The Pennsylvania State University, University Park 16802
†Department of Cellular and Molecular Physiology, The Pennsylvania State University, Hershey 17033
‡Pancosma S.A., CH-1280, Geneva, Switzerland

ABSTRACT

This experiment was conducted to investigate the effects of phytonutrients, compared with monensin as a positive control, on productivity, milk fatty acids, fat mobilization, and blood cells in lactating dairy cows. Thirty-six Holstein cows were used in a 9-wk randomized complete block design study. Following a 2-wk covariate period, cows were blocked by days in milk, parity, and milk yield and randomly assigned to 1 of 3 treatments (12 cows/treatment): 450 mg/cow per day of monensin (MO), 250 mg/cow per day of capsicum plus 450 mg/cow per day of MO (MOCAP), and 1,000 mg/cow per day of a mixture of cinnamaldehyde, eugenol, and capsicum (CEC). Dry matter intake and milk yield were not affected by treatment. Supplementation of CEC increased feed efficiency compared with MO, but did not affect feed efficiency on an energy-corrected milk basis. Milk composition (fat, protein, and lactose), milk fatty acid profile, and blood concentrations of nonesterified fatty acids and β-hydroxybutyrate were also not affected by treatment. The expression of hormone-sensitive lipase in adipose tissues tended to increase for MOCAP compared with MO. Counts of total white blood cell, neutrophils, lymphocytes, eosinophils, and basophils were not affected by treatment, although monocytes count tended to be decreased by CEC. Treatments had no effect on red blood cells, hemoglobin, and platelets. Results indicate that dietary supplementation of CEC and capsicum had no production or other effects in dairy cows, compared with MO, except CEC increased feed efficiency and tended to decrease blood monocytes count.
Key words: phytonutrient, milk yield, feed efficiency, dairy cow

INTRODUCTION

Phytonutrients (**PN**) are plant-derived bioactive compounds produced by the secondary metabolism in plants (Patra, 2012). It is well known that PN have antimicrobial effects and are used as self-defense agents in plants (Cowan, 1999). In studies with ruminants, PN have been used to modify ruminal fermentation, increase nutrient use efficiency, and enhance animal productivity (Calsamiglia et al., 2007). Some phenolic PN, such as cinnamaldehyde (**CIN**), eugenol (**EUG**), and capsicum (**CAP**), decreased acetate and increased propionate concentrations in ruminal contents of cattle (Cardozo et al., 2006; Yang et al., 2010a). Propionate improves dietary energy use efficiency by increasing energy supply through gluconeogenesis, and increased propionate concentration is associated with decreased methane production in ruminants (Aschenbach et al., 2010; Janssen, 2010). These ruminal effects of PN are similar to those of conventional rumen modifiers such as monensin (**MO**). As an ionophoric antibiotic, MO is known to selectively inhibit gram-positive bacteria, which results in decreased acetate and increased propionate concentrations in the rumen (Russell and Strobel, 1989).

In addition to ruminal effects, PN may have postruminal effects (Oh et al., 2017a). In studies with nonruminants, capsaicin, the main active compound in CAP, binds to its receptor in the intestine to induce host-mediated responses (Holzer, 2011). Capsaicin or CAP exhibited pro- and anti-inflammatory effects (Lee et al., 2011; Liu et al., 2013) and stimulated fat mobilization (Azhar et al., 2016) and digestive enzyme secretion (Srinivasan, 2016) in chicken, pigs, and rats. These effects could be expected in ruminants if CAP bypasses the rumen. In a study with dairy cows, abomasal infusion of CAP modulated the immune system by increasing T helper cells (Oh et al., 2013). Dietary supplementation of unprotected CAP enhanced energy availability by increasing fat mobilization without affecting ruminal fermentation (Oh et al., 2015). Ruminal escape of capsaicin was reportedly estimated between

Received January 13, 2018.
Accepted April 3, 2018.
[1]Corresponding author: anh13@psu.edu

15 and 33% depending on the dose amount in dairy cows (Oh et al., 2016).

Therefore, we hypothesized that PN may, due to their ruminal and postruminal effects, enhance animal productivity by improving nutrient use efficiency. The study investigated the ruminal effects of phenolic PN (CIN, EUG, and CAP) in comparison with MO and potential postruminal effects of CAP when supplemented together with MO. The objective of our study was to investigate the effects of PN alone or in combination with MO on feed intake, milk yield and composition, fat mobilization, and blood cells in lactating dairy cows.

MATERIALS AND METHODS

Animals and Treatments

The Pennsylvania State University Animal Care and Use Committee approved all procedures used in this experiment. The experiment was conducted at The Pennsylvania State University's Dairy Teaching and Research Center (University Park). The experiment involved 36 lactating Holstein cows (average milk yield = 46 ± 8.8 kg; BW = 676 ± 75.8 kg; and 120 ± 23.1 DIM at the beginning of the experiment) arranged in a randomized complete block design. Cows were housed in a sand-bedded freestall barn equipped with the Calan Broadbent Feeding System (American Calan Inc., Northwood, NH) for measuring individual feed intake. Cows were trained to use the Calan system before the beginning of the experiment and had free access to drinking water. The experiment lasted 9 wk, including a 2-wk covariate period followed by a 7-wk experimental period that included 3 wk for diet adaptation and 4 wk for data and sample collection. During the covariate period, cows were fed the herd diet, which consisted of (% of DM) 39.0% corn silage, 16.6% alfalfa haylage, 2.5% grass hay, 8.3% ground and 1.6% cracked corn, 7.5% solvent-extracted canola meal, 7.4% candy by-product meal, 5.8% heat-treated whole soybeans, 5% cane molasses, 3.3% cottonseed hulls, 2.7% mineral and vitamin premix, and 0.3% Optigen (Alltech Inc., Nicholasville, KY) as a slow-release urea. The covariate diet contained (% of DM) 14.9% CP, 31.2% NDF, 21.9% ADF, 44.4% NFC, and 1.56 Mcal/kg of NE_L. The experimental diet (Table 1) was formulated to meet or exceed, based on NRC (2001), the nutrient requirements of the cows based on their average DMI (30.2 kg/d), BW (671 kg), and milk yield (47.1 kg/d) and composition (3.80% milk fat, 3.20% true protein, and 4.78% lactose) during the covariate period.

Cows were blocked in blocks of 3 based on DIM, parity, and milk yield during the covariate periods. Cows within a block were randomly assigned to 1 of the following treatments (12 cows/treatment): 450 mg/d of MO (Rumensin, Elanco Animal Health, Greenfield, IN), 450 mg/d of MO plus 250 mg/d of a product containing 20% of CAP (XTRACT CapsXL, Pancosma, Geneva, Switzerland; **MOCAP**), and 1,000 mg/d of a mixture of 5.5% of CIN, 9.5% of EUG, and 3.5% of CAP (XTRACT Ruminant, Pancosma; **CEC**). Doses of PN were determined based on previous studies (Oh et

Table 1. Ingredient and chemical composition of the basal diet fed during the experiment

Item	Measurement
Ingredient, % of diet DM	
Corn silage[1]	41.0
Haylage[2]	13.0
Grass hay	5.00
Whole cottonseed	4.00
Corn grain, ground	9.30
Soybean seeds, whole heated[3]	7.00
Canola meal[4]	8.70
Soybean meal[5]	5.00
Molasses[6]	5.00
Vitamin and mineral premix[7]	2.00
Composition, % of DM (or as indicated)	
CP[8]	16.4
RDP[9]	10.4
RUP[9]	6.0
NDF[8]	32.1
ADF[8]	21.2
NE_L, Mcal/kg[8]	1.55
Ca[8]	0.7
P[8]	0.4
NFC[9]	43.1
Average NE_L balance,[10] Mcal/d	(3.6, 2.1, 0.8)
Average MP balance,[10] g/d	(213, 109, 68.0)

[1]Corn silage was 39.5% DM and contained (DM basis) 6.8% CP, 38.1% NDF, and 34.5% starch.

[2]Haylage was 36.8% DM and contained (DM basis) 20.2% CP and 45.0% NDF.

[3]Soybean seeds contained (DM basis) 37.4% CP.

[4]Canola meal contained (DM basis) 42.4% CP.

[5]Soybean meal contained (DM basis) 46.6% CP.

[6]Molasses (Westway Feed Products, Tomball, TX) contained (DM basis) 3.9% CP and 66% total sugar.

[7]The premix (Cargill Animal Nutrition, Cargill Inc., Roaring Spring, PA) contained (%, as-is basis) trace mineral mix, 1.88; MgO (54% Mg), 8.0; NaCl, 24.9; vitamin ADE premix (Cargill Animal Nutrition, Cargill Inc.), 0.41; limestone, 36.8; selenium, 0.13; and dry corn distillers grains with solubles, 29.0. Ca, 14.4%; P, 0.75%; Mg, 2.48%; K, 0.28%; S, 0.50%; Se, 12.8 mg/kg; Cu, 651 mg/kg; Zn, 3,433 mg/kg; Fe, 798 mg/kg, vitamin A, 195,290 IU/kg; vitamin D, 62,500 IU/kg; and vitamin E, 1,863 IU/kg.

[8]Values calculated using the chemical analysis (Cumberland Valley Analytical Services Inc., Maugansville, MD) of the ingredients of the diets.

[9]Estimated based on NRC (2001).

[10]Estimated based on NRC (2001) using actual DMI, milk yield, milk composition, and BW of the cows throughout the trial (monensin, monensin plus capsicum, and cinnamaldehyde, eugenol, and capsicum, respectively).