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Effects of a blend of essential oils, chitosan or monensin on nutrient intake and digestibility of lactating dairy cows

T.H.A. Vendramini[a], C.S. Takiya[a], T.H. Silva[a], F. Zanferari[a], M.F. Rentas[a], J.C. Bertoni[a], C.E.C. Consentini[a], R. Gardinal[a], T.S. Acedo[b], F.P. Rennó[a,*]

[a] Department of Animal Nutrition and Production, University of Sao Paulo, Pirassununga, Brazil
[b] DSM Nutritional Products Brazil Ltd., Sao Paulo, Brazil

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ABSTRACT

This study was undertaken to determine the effects of a blend of essential oils, chitosan or monensin on nutrient intake and digestibility, nitrogen utilization, microbial protein synthesis, ruminal fermentation, and blood profile of mid- to late-lactating Holstein cows. The secondary objective of this study was to evaluate the effects of additives on milk yield and composition of animals. Twenty-four multiparous cows (average 31.44 ± 4.83 kg/day of milk yield and 175.89 ± 99.74 days in milk, mean ± SD) were distributed into a replicated 4 × 4 Latin square experimental design. Periods consisted of 14 days of adaptation to treatments and 7 days of sampling. Cows were randomly assigned to receive one of the four treatments: (1) Control (CON); (2) Essential oils (EO), supply of 1 g/day of EO mixture (Crina® Ruminants—DSM Nutritional Products Brazil Ltd., Sao Paulo, Brazil; composed by thymol, guaiacol, eugenol, vanillin, salicylaldehyde and limonene); (3) Chitosan (CHI), dietary inclusion of 150 mg/kg BW of CHI; and (4) Monensin (MON), dietary inclusion of 24 mg/kg DM of sodic monensin (Monensin Tortuga—DSM Nutritional Products Brazil Ltd., Sao Paulo, Brazil). Treatments did not influence nutrient intake, milk yield and composition. Animals fed CHI showed higher DM digestibility than those fed EO. Cows fed MON or CHI had higher CP digestibility than cows fed EO. However, animals fed additives had similar nutrient digestibility compared to CON. Fecal nitrogen excretion was lower for cows fed CHI or MON than those fed EO, but the feed additives did not alter nitrogen excretion compared to CON. Treatments did not affect microbial protein synthesis and efficiency. Cows fed MON had lower acetate to propinate ratio than CON or EO. Blood profile was not altered by treatments. Feed additives did not influence nutrient intake, but altered nutrient digestibility and ruminal fermentation. Monensin shifted ruminal fermentation to a more energetically efficient pathway. Milk and solids yield were not affected by treatments.

Abbreviations: aADF, acid detergent fiber; aNDF, neutral detergent fiber; AST, aspartate aminotransferase; BFCA, branched chain fatty acids; CHI, chitosan; CON, control; CP, crude protein; DM, dry matter; ECM, energy corrected milk; EO, essential oils; FCM, fat corrected milk; GGT, gamma-glutamyl transferase; MON, monensin; N, nitrogen; NH_3-N, ammonia nitrogen; SD, standard error of the mean; VFA, volatile fatty acid.

* Corresponding author. Fax: +55 19 3565 4295.
E-mail address: francisco.renno@usp.br (F.P. Rennó).

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1. Introduction

Several products and technologies have been developed over the years to optimize livestock production and achieve the maximum profitability. Feed additives, including antibiotics, are used to manipulate the ruminal fermentation since the 1950s (Beeson and Perry, 1952). Antibiotics can be classified as non-ionophore and ionophore, according to the mechanism of action, in which the latter is the most used and researched by the scientific community. Ionophore antibiotics usually decrease energy and protein losses in ruminal environment and consequently improve animal performance (Calsamiglia et al., 2007).

Monensin is the most used ionophore in ruminant production, but the monensin utilization has been questioned due to the risk of resistant bacteria strains leading to concerns on public health. The European Union, considering the precautionary principle, banned the antibiotics as animal growth promoters (Regulation 1831/2003/EC). Therefore, alternative natural compounds have been developed with the purpose of performing similar effects of ionophores on animal production. Among the natural compounds, EO and CHI may be highlighted as potential rumen modulators.

Essential oils are aromatic liquids with antimicrobial properties extracted from plants by different methods, including fermentation and distillation (Chao et al., 2000). Essential oils have promised important results, since they had increased the propionate production in *in vitro* studies (Chaves et al., 2008; Busquet et al., 2005), and increased the milk yield of early lactating cows (Tassoul and Shaver, 2009). In addition, Kung Jr. et al. (2008) found an increase of 2.7 kg/day of fat corrected milk production of mid-lactating cows fed EO.

Chitosan is a non-toxic and biodegradable biopolymer commonly used in medicine and food preservation, mainly for its antimicrobial activities (Kong et al., 2010). Chitosan has attracted interest of nutritionists because demonstrated similar activity of ionophores as ruminal modulator, shifting the ruminal fermentation to a more energetically efficient pathway (Goiri et al., 2009a,b). Recently, Araújo et al. (2015) reported a linear increase of ruminal propionate concentration when beef steers received CHI. In addition, CHI increased DM, CP, and NDF digestibility in beef steers (Araújo et al., 2015).

The primary objective of the current study was to evaluate the effects of alternative additives to monensin on nutrient intake and digestibility, nitrogen utilization, microbial protein synthesis, ruminal fermentation, and blood profile of mid- to late-lactating Holstein cows. The secondary goal of this study was to determine the effects of additives on milk yield and composition of dairy cows. Our hypothesis was that cows fed alternative additives would have similar nutrient digestibility and ruminal fermentation of cows fed monensin.

2. Materials and methods

This study was approved by the Bioethics Committee of the School of Veterinary Medicine and Animal Sciences, University of Sao Paulo, Pirassununga, Brazil (approval number: 7072050214).

2.1. Animals, experimental design, and treatments

The experiment was carried out at the Dairy Cattle Research Laboratory, University of Sao Paulo, Pirassununga, Brazil. Twenty-four multiparous Holstein cows (average 31.44 ± 4.83 kg/day of milk yield and 175.89 ± 99.74 days in milk, mean $\pm$ SD) were distributed into a replicated 4×4 Latin square experimental design. Four squares were composed by 16 cows without cannulas, and two squares were composed by 8 cows ruminal fistulated to access ruminal fermentation parameters. Periods consisted of 14 days of adaptation to treatments and 7 days of sampling. Cows were randomly assigned to receive one of four treatments: (1) Control (CON), basal diet with no additive; (2) Essential oils (EO), supply of 1 g/day EO mixture (Crina® Ruminants, DSM Nutritional Products Brazil Ltd., Sao Paulo, Brazil: composed by thymol, guaiacol, eugenol, vanillin, salicylaldehyde and limonene), (3) Chitosan (CHI), dietary inclusion of 150 mg/kg BW of CHI; and (4) Monensin (MON), dietary inclusion of 24 mg/kg DM of sodic monensin (Monensin Tortuga, DSM Nutritional Products Brazil Ltd., Sao Paulo, Brazil). The CHI supplied during all the experiment had the following technical specifications: apparent density of 0.64 g/mL, 20 g/kg of ash, 7.0–9.0 of pH, viscosity < 200 cPs and deacetylation level of 950 g/kg (Polymar Ciencia e Nutricao S/A®, Fortaleza, Brazil). The dietary inclusion of MO and CHI were based on previous studies of our research group (Gandra et al., 2010; Araújo et al., 2015) and the dosage of EO was based on literature data (Tassoul and Shaver, 2009; Benchaar et al., 2007), besides the manufacturer's recommendations. The average supply of CHI was 89 g/day, and the average supply of MON was 0.54 g/day.

All additives were weighed daily and hand mixed into the concentrate before the morning feeding. Diet (Table 1) was formulated according to NRC (2001) and was provided as total mixed ration at 0700 h and 1300 h. Throughout the experiment cows were housed in individual pens (17.5 m^2), with sand beds, individual feed bunks and forced ventilation.

2.2. Nutrient intake, milk yield and composition

The feed offered and refusals of each cow were weighed daily to determine feed intake and restrict 50–100 g/kg of orts (on an as-fed basis), not limiting DMI. Ingredients were collected during the concentrate mixture, and silage and ort samples of each cow were collected daily during the sampling periods to form a composite sample. Immediately after collections,