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Can by-products replace conventional ingredients in concentrate of dairy goat diet?

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ABSTRACT

Intensive dairy goat production in the Mediterranean basin is based on imported conventional ingredients to be included in concentrates. Fourteen Murciano-Granadina goats in the middle of the third lactation were allocated into 2 groups of 7 animals each fed, respectively, a control diet based on alfalfa hay and concentrate in a 40:60 ratio, and a diet in which the concentrate included tomato fruits, citrus pulp, brewer's grain and brewer's yeast (T100CBY) to study the effect of diet on nutrient utilization, ruminal fermentation, purine derivatives excretion in urine, milk yield and composition, and methane emissions. No effect of the diet on total dry matter intake was observed. Digestibility of neutral detergent fiber and acid detergent fiber were higher for T100CBY compared with the control diet. The N in feces and urine was lower and balance and retained N were higher in animals fed T100CBY than the control diet. Milk protein N and energy were similar for both diets. Metabolizable energy per energy intake and metabolizable energy per digestible energy were higher and energy in methane was lower with diet T100CBY than with the control. Milk yield and composition were not affected by diet, with the exception of protein, casein, and total solids, which were higher for diet T100CBY than the control. Diet T100CBY promoted less saturated fatty acids and higher mono- and polyunsaturated fatty acids in milk than the control diet. Diet T100CBY produced less methane and NH_3 concentration in the rumen, higher propionate, and a lower acetate-to-propionate ratio without an effect on the volatile fatty acid concentration. The concentrate with by-products did not affect urinary excretion of total purine derivatives, reduced feeding costs, and increased profit margin by 14 and 16% compared with the control. The mixture of tomato fruits, citrus pulp, brewer's grain, and brewer's yeast could replace 47% of conventional ingredients (corn, wheat bran, sunflower meal, and soy flour) in the concentrate of the dairy goat diet, reducing feeding cost and methane production, leading to a healthier fatty acids profile in milk without compromising nutrient utilization or milk yield.
Key words: goat, by-product, methane, milk

INTRODUCTION

Dairy goat production is of increasing interest in the Mediterranean basin due to the exponential growth of market demand for milk and dairy products (Haenlein, 2001). Scarcity of pastures, especially during drought periods, have led to more intensive dairy goat production systems and imported conventional ingredients to be included in concentrates. The high and variable prices of conventional ingredients in recent years (FAO, 2011) has driven the attention of ruminant nutritionists toward local alternative resources (Romero-Huelva et al., 2012; Megersa et al., 2013) to reduce production costs (Ben-Salem and Znaidi, 2008) without altering yield and product quality. Additionally, environmental issues associated with both livestock production and by-products accumulation (Greenwood et al., 2012) could be prevented.

In the Mediterranean area, greenhouse horticulture represents about 15% of the world production, Spain being the main producer. This horticulture generates huge amounts of wastes, mainly tomato fruit wastes (about 350,000 t/yr), available during the whole year. About 24% of world production of citrus is concentrated in Mediterranean countries. In addition, most developed countries continuously produce these and other abundant by-products, such as brewer's grain and brewer's yeast. Beer is the fifth most consumed beverage in the world, with an estimated annual world production of about 1.34 billion hL (Bampidis and Robinson, 2006). The use of tomato wastes, citrus pulp,

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brewer's grain, and brewer's yeast for ruminant feeding has been explored (Fegeros et al., 1995; Angulo et al., 2012; Romero-Huelva et al., 2012), but no information exists on the effect of a mixture of those by-products. The replacement of conventional ingredients with a combination of alternative sources of protein and structural carbohydrates and NSC could promote different ruminal fermentation or N and energy balances patterns. The high moisture of by-products is a limitation for their storage, inclusion in diets, and for logistics, which is additionally more expensive. The development of appropriate drying methods could help to overcome that limitation.

Interest has recently increased for dietary strategies that could reduce methane emissions by ruminants (Romero-Huelva et al., 2012; Knapp et al., 2014; Caro et al., 2016). Methane is an important greenhouse gas, which otherwise represents a significant energy loss for the ruminant (2 to 12% of the gross energy intake). Globally, goat milk and meat production are responsible for ~174.5 million t of carbon dioxide equivalents, which are mainly associated with CH_4 and N_2O emissions, respectively, from enteric fermentation and manure management (Zervas and Tsiplakou, 2012; Opio et al., 2013). Goats produce 11.9 million t of milk, of which the associated greenhouse gas emissions are 62.4 million t of CO_2 equivalents (Opio et al., 2013; Marino et al., 2016), representing around the 0.85% of total emissions from domestic ruminants.

Research regarding ruminant nutrition has been focused as well on dietary strategies that could reduce the formation of some SFA and increase the concentration of UFA in ruminant products. As far as we know, few studies have investigated the effect of diets based on the use of by-products on milk fatty acid composition (Molina-Alcaide et al., 2010; Abbeddou et al., 2011, 2015; Romero-Huelva et al., 2012) or methane emissions by ruminants (Moate et al., 2011; Romero-Huelva et al., 2012; Romero-Huelva and Molina-Alcaide, 2013).

Our hypothesis was that a mixture of dried tomato fruits, citrus pulp, brewer's grain, and brewer's yeast could partially replace conventional ingredients in concentrates for dairy goat, decreasing feeding cost and methane emissions and improving the quality of the milk fatty acid profile without compromising ruminal fermentation, nutrients utilization, or milk yield. Thus, the aim of the present work was to study, in dairy goats, the effect of replacing 47% of conventional ingredients in the concentrate with agro-industrial by-products on milk yield and composition, nutrients utilization, rumen fermentation, and methane emissions.

MATERIALS AND METHODS

Animals and Diets

Fourteen Murciano-Granadina dairy goats in the middle of the third lactation were selected and divided into 2 homogeneous groups of 7 goats each based on BW (44.5 ± 3.39 kg of BW), average voluntary feed intake (88.7 g of DM/kg$^{0.75}$), milk production in previous lactations (471.5 ± 23 kg of milk per 210 ± 30 d of lactation), and milk yield at the beginning of the experiment (1,472 ± 123.1 g of milk/d). Animals were placed in individual boxes.

Each group was randomly assigned to 1 of the following diets, with composition shown in Table 1. The control diet was based on alfalfa hay and a commercial concentrate in a 40:60 ratio; the second diet (**T100CBY**) was based on a 40:60 ratio of alfalfa hay and a concentrate in which 47% of a mixture of corn, wheat bran, sunflower meal, and soy flour (250, 50.0, 120, and 50.1 g/kg of DM, respectively) was replaced with a mixture of tomato fruits, citrus pulp, brewer's grain, and brewer's yeast (250, 100, 70, and 50 g/kg of DM, respectively). Diets were formulated to be isoenergetic and isoproteic. By-products were provided by the company Aspero S.A. (Sevilla, Spain). Tomato fruits were cut and dried at 65°C in a convection oven under controlled conditions (ZoitechLab SL, Madrid, Spain). All the other by-products were also dried at 65°C and ground to be included in concentrate pellets.

The specific N and energy requirements of Murciano-Granadina goat breed (Aguilera et al., 1990; Prieto et al., 1990) were considered in the diets formulation. The amount of alfalfa hay and concentrate supplied to the animals were sufficient to allow daily milk production of up to 2 kg/goat. The total amount supplied during the adaptation period was 110.7 g of DM/kg of metabolic BW (BW$^{0.75}$), with refusals representing 20 to 25% of distributed feeds. The amount supplied when animals were placed in metabolism crates was 106.3 g of DM/kg of BW$^{0.75}$ and the average intake was 88.5 ± 3.02 g of DM/kg of BW$^{0.75}$.

Animals were cared and handled in accordance with the Spanish guidelines for experimental animal protection (Government of Spain, 2013) in line with the European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (European Commission, 2012). All procedures were approved by the Ethic Committee for Animal Experimentation of the Spanish Research Council and Junta de Andalucía (24/05/2016/091 and 22/06/2016/115)