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Multivariate analysis of characteristics associated with performance of dairy goats fed integral mango meal

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ABSTRACT

Factor analysis was used for reduction of dimensionality and to obtain latent variables, constructed from linear combinations of feeding behavior characteristics, physiological and performance, to evaluate the effects of diets containing integral mango meal (IMM) replacing corn (0, 330, 660, and 1000 g/kg) for dairy goats. Eight lactating Saanen crossbred goats (48.7 ± 1.99 kg of BW) were introduced in the experiment 48 days postpartum and maintained up to 124 days of lactation. The latent variable composed of behavioral characteristics and milk performance showed a cubic effect for the tested diets ($P < 0.05$), with a maximum point for milk performance with 78 g/kg of replacing corn with integral mango meal, and a minimum point with 763 g/kg replacing corn with integral mango meal. Similarly, there was a linear increase ($P < 0.01$) in rumination and chewing activities with replacement levels. The latent variable composed of metabolic characteristics and milk performance did not ($P > 0.05$) detect the effect of the replacement of corn with integral mango meal. From the factor analysis, it was possible to reduce the dimensionality of the set of data. Considering that the feeding behavior characterized by the amount of meals and activities of rumination interfered the performance of dairy goats, may be recommended replacing 78 g/kg of corn by integral mango meal.

1. Introduction

The dairy performance can be affected by factors related to animal (breed, age, metabolic profile, reproduction, feeding behavior), nutrition (source and composition of food) and environment (season, air temperature, installation) (Haenlein, 2007; Raynal-Ljutovac et al., 2008; Tronco, 2010). According to Coulon and Priolo (2002) the feeding, among all factors, is the one that most affects the production and composition of milk.

The metabolic activities for utilization of nutrients and milk synthesis are closely related to the physiological adaptability of goats to various edaphoclimatic conditions throughout the evolution of ruminants (Morand-Fehr et al., 2007). Thus, the combination of the animal potential for energy demand and the physical capacity of the digestive tract determines the voluntary intake of food (Resende et al., 2008), and in the case of lactating animals the energy intake is a major factor determining the synthesis and composition of milk (Seal and Reynolds, 1993). Thus, the replacement of energetic food by alternative ingredients in the diet of lactating animals can provide impacts on yield and composition of milk, which can be detected from the evaluation of feeding behavior and metabolic profile.

Therefore, a large number of variables, which quantify potential changes in production, physiological and behavioral patterns of animals can be measured and analyzed. For this reason, the use of multivariate analysis techniques, such as factor analysis, become attractive as they allow a reduction of the number of variables into a smaller number of new hypothetical variables (factors), which can be used to assess the effects of inclusion of dietary ingredient.

Thus, the aim of this study was to assess the effects of diets containing integral mango meal replacing corn (0, 330, 660, 1000 g/kg on DM basis) for lactating goats using factor analysis in order to

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reduce the dimensionality of data and obtain latent variables, built from linear combinations of feeding behavior, physiological and performance characteristics.

2. Material and methods

The experiment was conducted in the Goat Sector of the Animal Science Department of the Federal Rural University of Pernambuco (UFRPE), Recife, Brazil.

2.1. Experimental diets

The diets were formulated to meet dairy goat requirements in early lactation according to the National Research Council (NRC, 2007). The forage:concentrate ratio was 60:40 on a dry matter (DM) basis with Tifton hay as the forage. The diets consisted of four concentrate replacement levels of corn by integral mango meal, 0, 330, 660, and 1000 g/kg on a DM basis. The ingredients and chemical composition of the experimental diets are shown in Table 1.

To obtain the integral mango meal, the fresh entire fruits (pulp, peel, and seed) were ground in a forage machine, dehydrated under the sun for 48 h, and were then ground passing through a 10 mm screen.

2.2. Animals, management, and sample collection

The management and care of animals were performed in accordance with the guidelines and recommendations of the Committee of Ethics on Animal Use (CEUA) at the UFRPE, under the license number 143/2014. To determine nutrient intake and milk performance, eight crossbred Saanen goats with an average initial body weight (BW) of 48.7 ± 1.99 kg and 48.0 ± 2.0 days in lactation were distributed across a 4 × 4 double Latin square design, with four treatments, four animals and four periods. The feed was provided in two daily meals at 7h00 and 16h00 in a sufficient quantity to obtain 10% orts. The trial lasted 76 days and the four experimental periods lasted 19 days and were divided as follows: 14 days for adaptation to the diets and 5 days to collect supplied feed, and ort samples.

Orts were removed for each animal each day before the morning meal and were weighed, sampled, placed inside plastic bags, and frozen at −18 °C. The supplied feed was sampled three times each week and also placed inside plastic bags and frozen at −18 °C. At the end of each experimental period, the feed samples, and orts were thawed and subjected to pre-drying at 60 °C for 72 h and were then ground in a Willey-type knife mill (TE-625, TECNAL, SP, Brazil) with a 1 mm mesh. Composite samples were saved for each animal on a dry weight basis from each time period.

Table 1
Ingredients proportion and chemical composition of the experimental diets.

Items	Replacement levels (IMM[a] replacing corn g/kg)			
	0	330	660	1000
Ingredient (g/kg)				
Tifton hay	600	600	600	600
Integral mango meal	0	100	200	300
Ground corn	300	200	100	0
Soybean meal	70.6	69.1	67.7	66.2
Urea	9.4	10.9	12.3	13.8
Dicalcium phosphate	7	7	7	7
Mineral mix[b]	13	13	13	13
Diet composition (g/kg of DM)				
Dry matter (g/kg)	882	886	889	893
Organic matter	927	925	923	921
Crude protein	140	140	140	141
Ether extract	22.6	22.5	22.4	22.2
Non-fibrous carbohydrates	315	304	293	283
Neutral detergent fiber	502	516	530	544
Acid detergent fiber	254	265	276	286
Cellulose	219	210	207	205
Lignin	36.5	41.7	47.0	52.3
Total phenols	–	39.6	79.1	119
Condensed tannins	–	3.10	6.2	9.2
Total digestible nutrients	639	624	611	601

[a] Integral mango meal.
[b] Nutrients/kg of product: Vitamin A – 135,000 U.I.; Vitamin D3 – 68,000 U.I.; Vitamin E – 450 U.I.; Calcium – 240 g; Phosphorus – 71 g; Potassium – 28.2 g; Sulfur – 20 g; Magnesium – 20 g; Copper – 400 mg; Cobalt k 30 mg; Chrome – 10 mg; Iron – 250 mg; Iodine – 40 mg; Manganese – 1,350 mg; Selenium – 15 mg; Zinc – 1,700 mg; Fluorine – 710 mg.

2.3. Feeding behavior

The observations concerning the ingestive behavior of animals were performed by using the instantaneous scanning method proposed by Martin and Bateson (1986). Goats were observed every 5 min for 24 h each day starting immediately after the morning feeding, being three days of observation in each period, totalizing 72 h of observation. The activity of each goat was recorded as rumination, feeding and idling. Total chewing time was calculated as the sum of eating and ruminating time. A meal was defined as at least one observation of feeding activity occurring after at least 20 min without feeding activity, according to Wangsness et al. (1976). A period of rumination was defined as at least 5 min of rumination occurring after at least 5 min without ruminating activity.

The feed and rumination efficiencies (kg/h) of DM and NDF were calculated by dividing the intake of each of these nutrients by the total feeding time (feed efficiency) or rumination time (rumination efficiency).

2.4. Metabolic profile

Blood samples were collected four hours after the first meal on the last collection day of each period. The aliquots of serum from blood samples were obtained by centrifugation at 2500 rpm and were stored in Eppendorf's at −20 °C until performing the analyses for the biochemical doses of metabolites (glucose and total cholesterol), triglycerides, proteins (albumen and total protein), enzymes (aspartate aminotransferase – AST and gamma-glutamyl transferase – GGT), substances related to kidney functions (urea and creatinine), and minerals (calcium, phosphorus, and magnesium); this was accomplished by using the Doles® commercial kits and the colorimetric system in a semiautomatic biochemical analyzer (Doles D250, DOLES®, Brazil).

2.5. Milk performance

Goats were hand milked twice daily at 06 h00 and 15 h00 and milk yield was recorded during the 5 days of data collection. Milk samples were collected and pooled by proportion according to the milk yield at each milking. Milk samples were analyzed for fat, protein, and lactose concentration using infrared analysis (Bentley-2000, Bentley instrument, Inc. Minnesota, USA). Total solids were determined using the oven method (AOAC, 1990).

2.6. 2.6. Chemical analysis

DM, organic matter (OM), and crude protein (CP) analysis were performed according to the AOAC (1990), method number 934.01 for DM, 930.05 for OM, and 981.10 for CP. Ether extract (EE) was analyzed by Soxhlet extraction with petroleum ether (AOAC, 1990). The concentration of neutral detergent fiber was assayed with a heat-stable amylase and corrected for ash