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Short Communication

Performance of dairy goats fed diets with dry yeast from sugar cane as protein source[1]

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ABSTRACT - The effects of inactive dry yeast (*Saccharomyces cerevisiae*) from sugar cane were studied in 18 primiparus Saanen dairy goats (51.07±1.43) on dry matter intake and digestibility, milk production and quality. Animals were distributed in a completely randomized design during 90 days (from day 60 of milking). Diets were composed of soybean meal; soybean meal + dry yeast; or dry yeast, as protein sources, and ground corn, mineral supplement and corn silage (40%). Animals fed the dry yeast diet showed lower intake of dry matter (DM), organic matter (OM), crude protein, ether extract and neutral detergent fiber. Diets did not influence milk yield; however the milk production efficiency (kg of milk produced/kg of crude protein ingested) was better in goats fed the dry yeast diet. Acidity, somatic cell counts and milk urea nitrogen values were not affected by treatments. Animals fed the soybean + dry yeast diet had higher fat and total solids than those fed the dry yeast diet. The digestibility of DM, OM and total carbohydrate was lower for soybean only and soybean + dry yeast diets. Total digestible nutrients were higher for dry yeast and soy bean diets than soybean + dry yeast diet. Dry yeast from sugar cane is a good alternative protein source for feeding lactating dairy goats and can be recommended because it maintains the production performance.

Key Words: digestibility, goats, milk quality, *Saccharomyces cerevisiae*

Introduction

Supply of protein is important in dairy ruminant production systems because this is the second limiting nutrient. Thus, the search for new sources of protein should provide livestock with alternative foods.

Yeasts are unicellular organisms that reproduce asexually by budding and develop in the alcoholic fermentation (Yara et al., 2006). In Brazil, the ethanol from sugar cane is usually produced using strains from *Saccharomyces cerevisiae*, and the industrial process produces a large amount of yeast that can be sold live, inactive (dry) and as derivatives.

The inactive dry yeast has 26 to 32% of cell wall that consists of complex carbohydrates (beta-glucans and mannans). It is rich in B vitamins (Yamada et al., 2003), among which are vitamins B1, B2, B6, pantothenic acid, niacin, folic acid and biotin. Depending on the strains used in the fermentation process and extraction techniques, dry yeast can provide about 42% crude protein (Butolo, 2002). Therefore, this feedstuff can be a good source of protein for livestock animals.

Early experiments were performed to evaluate the use of dry yeast as dietary protein source in diets for broiler chicks (Generoso et al., 2008), pigs (Junqueira et al., 2008), cattle (Messana et al., 2009), sheep (Aguiar et al., 2007) and meat goats (Lima et al., 2011). However, data on dairy goats are not found.

This trial was performed with the objective of evaluating performance and milk quality of primiparous Saanen goats fed diets with inactive dry yeast (*Saccharomyces cerevisiae*) from sugar cane as an alternative protein source.

Material and Methods

The study was performed at the Fazenda Experimental de Iguatemi, from the Universidade Estadual de Maringá, south Brazil. Eighteen primiparus Saanen goats (51.07±1.43) randomly distributed in a completely randomized design

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were used to evaluate the effects of replacement of soybean meal by inactive dry yeast in diets. The experimental period was composed of 90 days (from the 60th day of milking). Animals were allocated to single pens. Goats were weighed at the beginning of the trial and every 15 days after the morning milking and before feeding.

Diets were composed of soybean meal, soybean meal + dry yeast and dry yeast as protein source. The other ingredients were ground corn, mineral supplement and corn silage with 40:60 of forage to concentrate ratio (Tables 1 and 2).

Diets were formulated according to the AFRC (1998) for a milk production of 3.0 kg/d and were offered twice a day: 50% at 9 a.m. and 50% at 4 p.m. The supplied feeds and orts were weighed daily to calculate voluntary intake. Approximately 100 g/kg were allowed in orts. Water was offered *ad libitum*. Goats were milked twice daily (7:30 a.m. and 3:00 p.m.) and the milk yield of individual goats was recorded at each milking.

Samples of feeds and orts were taken once every two weeks and then frozen (-20 ºC). Samples of feces (50 g) were collected for five consecutive days at intervals of 26 hours, and then stored at -20 ºC until use. These samples were pooled for each animal after drying (55 ºC) for subsequent analysis.

Samples (feed , orts and feces) were oven-dried (55 °C for 72 h), then ground in a knife mill to pass through a 1-mm screen sieve (Wiley mill model 4, Arthur H. Thomas, Philadelphia, PA). Dry matter was evaluated according to method no. 934.01 of AOAC (1998). Organic matter was determined by combustion in a muffle furnace according to method no. 942.05 of AOAC (1998). Total nitrogen (TN)

Table 1 - Chemical composition of the feeds

Item	Ingredients			
	Corn silage	Ground corn	Soybean meal	Dry yeast
Dry matter (g/kg)	295.6	882.2	881.5	933.0
Organic matter (g/kg of DM)	952.9	989.0	933.3	954.1
Ash (g/kg of DM)	47.1	11.0	66.7	45.9
Crude protein (g/kg of DM)	72.9	84.3	506.8	428.6
Rumen degradable protein (g/kg of DM)[1]	51.0	40.5	329.4	428.6
Ether extract (g/kg of DM)	19.9	37.1	21.8	4.1
Neutral detergent fiber (g/kg of DM)	621.8	160.1	138.6	-
Acid detergent fiber (g/kg of DM)	360.5	36.7	81.5	-
Total carbohydrates (g/kg of DM)	860.0	867.6	404.7	533.2
Total digestible nutrients (g/kg of DM)[2]	629.2	795.2	765.0	765.0

[1] NRC (2001).
[2] Calculated as described by Chandler (1990).

Table 2 - Ingredients and chemical composition of experimental diets

	Diets		
	Soybean meal	Soybean meal + Dry yeast	Dry yeast
Ingredients (g/kg of DM)			
Corn silage	400.0	400.0	400.0
Ground corn	405.0	387.0	362.0
Soybean meal	185.0	102.0	-
Dry yeast	-	102.0	229.0
Limestone	-	0.5	2.6
Dicalcium phosphate	10.0	9.0	6.5
Mineral mixture[1]	30.0	30.0	30.0
Chemical composition			
Dry matter (g/kg)	649.9	656.1	657.8
Organic matter (g/kg of DM)	943.6	938.5	939.4
Ash (g/kg of DM)	56.4	61.5	66.8
Crude protein (g/kg of DM)	160.3	154.4	150.0
Rumen degradable protein (g/kg of DM)	97.7	113.4	133.2
Ether extract (g/kg of DM)	23.4	20.9	16.6
Neutral detergent fiber (g/kg of DM)	335.9	320.2	298.4
Acid detergent fiber (g/kg of DM)	176.6	166.3	159.4
Total carbohydrates (g/kg of DM)	759.9	763.2	772.9
Total digestible nutrients (g/kg of DM)	715.3	715.5	714.7

[1] Chemical composition (per kg of product): vitamin A - 135,000 UI; vitamin D3 - 68,000 UI; vitamin E - 450.00 UI; Ca - 240 g; P - 71 g; K - 28.2 g; S - 20 g; Mg - 20 g; Cu - 400 mg; Co - 30 mg; Cr - 10 mg; Fe - 2,500 mg; I - 40 mg; Mn - 1,350 mg; Se - 15 mg; Zn - 1,700 mg; F - 710 mg (max); Citric acid (2%) solubility of phosphorus 95% (min). (Commercial product).

determination used a Tecnal TE-036/1 (Tecnal, Piracicaba, São Paulo, Brazil) following method no. 988.05 of AOAC (1998) and crude protein (CP) was estimated as TN × 6.25. Ether extraction in diets was conducted with Tecnal TE-044/1 according to the method no. 920.39 of AOAC (1998). The neutral detergent fiber (NDF) was evaluated as described by Mertens (2002) using a heat-stable α-amylase, without using sodium sulphite. Procedures for NDF determination were adapted to the Ankom^{200} filter bag technique (Ankom, 2011). The acid detergent fiber (ADF) content was determined according to AOAC (1998) method no. 973.18.

The dietary rumen degradable protein (RDP) content was calculated according to the NRC (2001) model. The values considered were 70, 48, 65 and 100 g RDP/100g CP for corn silage, ground corn, soybean meal and dry yeast, respectively.

Total carbohydrates (TC) and total digestible nutrients (TDN) were estimated according to equations described by Sniffen et al. (1992): TC (g/kg DM) = 1000 - (CP + EE + ash) and TDN = dCP + (2.25 × dEE) + dTC, where dCP = digestible crude protein, dEE = digestible ether extract and dTC = digestible total carbohydrates.

Indigestible NDF (iNDF) was used as an internal marker to estimate fecal output and apparent nutrient digestibility. For iNDF analysis, 0.5 g (1 mm) of period samples (fecal, orts and feeds) were incubated *in situ* (144 h) in the rumen goat within nylon bags (F57 Ankom) followed by neutral detergent analysis (Mertens, 2002) by an Ankom^{200} Fiber Analyzer (Ankom Technology Corp., Fairport, NY).

Milk was sampled monthly from two consecutive milkings, preserved with 2-bromo-2-nitropropane-1,3-diol at 4 ºC for chemical composition determination. Other samples of milk were taken monthly from four consecutive milkings and were frozen (-20 ºC) to determine milk urea nitrogen.

The protein, fat, lactose and total solids contents in milk were estimated by infrared spectroscopy (Bentley model 2000; Bentley Instrument Inc., Chaska, MN). Yield of fat-corrected milk was calculated according to the equation reported by Gravert (1987): FCM (3.5%) = 0.433MY + 16.218FY, where: FCM: fat-corrected milk; MY: milk yield (kg/day); FY: fat yield (kg/day).

Milk somatic cells counts were obtained using an electronic counter (Somacount 500, Chaska, MN) as described by Voltolini et al. (2001). At the same time milk acidity using the Dornic solution was measured according to the AOAC (1998; method no 947.05). The milk urea nitrogen content was evaluated by enzymatic-colorimetric method (Bergmeyer, 1985).

The data obtained were analyzed by variance analysis (α = 0.05) and means were compared using the Tukey test through the SAEG system (version 9.1), with the general model: $Y_{ij} = \mu + D_i + e_j$; where: Y_{ij} = the dependent variable, μ = general constant; D_i = effect of diet i, i = soybean meal, soybean + dry yeast, and dry yeast; and e_j = random error.

Results and Discussion

Dry matter and organic matter intakes of the dry yeast diet were lower (P<0.05) than soybean + dry yeast (Table 3). Goats are able to choose food and they do it selecting feed on the basis of apprehension ease and sensorial characteristics (Provenza et al., 2003). Dry yeast has very fine texture and peculiar smell from sugar cane and it may have contributed to the reduction in dry matter intake. However, these differences seem to be more related to slight variation for body weight of animals within each diet because when the dry matter intake was calculated as percentage of body weight there was no difference (P>0.05) between diets.

Rodrigues et al. (2007) evaluated the intake of Alpine goats (57.14 kg BW) fed diets containing levels of crude protein and net energy and found 1.98 kg of dry matter intake on average. Zambom et al. (2008) observed dry matter intake of 2.21 kg in Saanen goats (75.7 kg BW) fed diets with soybean hulls replacing ground corn and corn silage

Table 3 - Body weight, dry matter and nutrients intake of Saanen goats fed diets with dry yeast as protein source

Item	Diets			P-value	SEM
	Soybean meal	Soybean meal + Dry yeast	Dry yeast		
BW (kg)	53.73	49.78	49.69	-	1.432
DMI (kg/d)	1.93ab	1.97a	1.72b	0.030	0.064
DMI (g/kg of BW)	36.3	39.6	35.0	0.158	0.965
OMI (kg/d)	1.82ab	1.85a	1.61b	0.029	0.060
CPI (kg/d)	0.32a	0.31a	0.26b	0.044	0.010
EEI (kg/d)	0.05a	0.05a	0.03b	0.000	0.001
NDFI (kg/d)	0.61a	0.60a	0.48b	0.002	0.024
TCI (kg/d)	1.46	1.50	1.33	0.369	0.039
TDNI (kg/d)	1.34	1.30	1.24	0.254	0.091

[a,b]Means with different superscripts in a row differ (P<0.05) by Tukey test.
SEM = standard error of the mean; BW = body weight; DMI = dry matter intake; OMI = organic matter intake; CPI = crude protein intake; EEI = ether extract intake; NDFI = neutral detergent fiber intake; TCI = total carbohydrates intake; TDNI = total digestible nutrients intake.

as roughage (40%). These results are similar to results from this trial and are also related to body weight of animals.

Crude protein, ether extract and neutral detergent fiber intakes were lower (P<0.05) for dry yeast diet compared with other diets. It may be the result of the difference observed in dry matter intake and especially of diets composition (Table 2), where ether extract and neutral detergent fiber contents were reduced by dry yeast inclusion. Even though the dry yeast diet showed lower crude protein intake, the intake obtained met the requirements for maintenance and milk production.

There were no differences (P>0.05) between diets as to total carbohydrates intake (Table 3), and the average value was similar to the observed by Fonseca et al. (2006) in dairy goats (1.38 kg/day) that were fed diets with protein levels.

Diets did not influence (P>0.05) milk yield; notwithstanding, the milk production efficiency (kg of milk produced/kg of crude protein ingested) was better (P<0.05) in goats fed the dry yeast diet (Table 4). Considering that diets did not influence the total digestible nutrients intake (Table 3), this can be related to the content of rumen degradable protein (RDP) of the diets. Protein is the second limiting nutrient for milk production and dry yeast diet provided more RDP, which contributes to microbial growth and thus contributing to milk production.

The fat milk content was higher (P<0.05) in goats fed the soybean + dry yeast diet compared with dry yeast diet. However, milk protein and lactose were not affected (P>0.05) by diets (Table 4).

Milk protein is strongly influenced by polymorphisms in the locus α_{S1}-casein in goats (Greppi et al., 2008) and lactose is synthesized and secreted at the same rate as the milk (Pulina et al., 2008). Thus, the levels of these milk components are, usually, constant in the milk. Unlike milk protein and lactose, fat is the milk component most sensitive to changes in nutrition of animals (Pulina et al., 2008), as observed in the current experiment. Furthermore, these differences can be associated with the lower NDF intake showed by goats on the dry yeast diet (Table 3).

As a consequence of the change in milk fat, goats fed dry yeast had lower (P<0.05) milk total solids than goats fed soybean + dry yeast (Table 4). There was no significant treatment effect (P>0.05) on acidity (17.87ºD), somatic cell counts (3.18 $\log_{10}$) or milk urea nitrogen (15.54 mg/dL).

The digestibility coefficients of dry matter, organic matter and total carbohydrates were highest (P<0.05) for the dry yeast diet (Table 5). This diet has more rumen degradable protein than the soybean and soybean + dry yeast diets, which may have provided better utilization of dietary energy and protein improving the digestibility of the rations.

Similar results were reported by Lima et al. (2011), who evaluated the digestibility of diets with inactive dry yeast replacing soybean meal in finishing kids. In this experiment, improvement was observed in the digestibility of dry matter,

Table 4 - Milk yield and composition

Item	Diets			P-value	Mean
	Soybean meal	Soybean meal + Dry yeast	Dry yeast		
Milk yield (kg/d)	2.3	2.3	2.2	0.923	0.119
FCM (kg/d)	2.1	2.3	2.0	0.954	0.115
MPE	7.1b	7.3b	8.7a	0.017	0.201
Fat (g/kg)	30.9ab	35.5a	28.1b	0.004	0.768
Protein (g/kg)	27.8	27.4	26.2	0.279	0.412
Lactose (g/kg)	40.9	40.5	40.5	0.972	0.396
Total solids (g/kg)	108.6ab	112.2a	102.6b	0.022	1.261

[a,b]Means with different letters in a row or column differ (P<0.05) by Tukey test.
FCM = 3.5% Fat-corrected milk; MPE = milk production efficiency (kg of milk produced/kg of crude protein ingested).

Table 5 - Digestibility coefficients (kg/kg) and total digestible nutrients (g/kg) in the experimental diets

Item	Diets[1]			P-value	SEM
	Soybean meal	Soybean meal + Dry yeast	Dry yeast		
DM	0.669b	0.644b	0.710a	0.001	0.006
OM	0.696b	0.670b	0.732a	0.002	0.006
CP	0.673	0.662	0.704	0.154	0.009
EE	0.810	0.774	0.760	0.108	0.009
NDF	0.493	0.488	0.507	0.874	0.010
TC	0.697b	0.669b	0.738a	0.001	0.006
TDN	685a	651b	707a	0.001	4.849

[a,b]Means with different superscripts in a row differ (P<0.05) by Tukey test.
DM = dry matter. OM = organic matter; CP = crude protein; EE = ether extract; NDF: neutral detergent fiber; TC = total carbohydrates; TDN = total digestible nutrients; SEM = standard error of the mean.

organic matter and total carbohydrate in diets. To heifers, Martins et al. (2000) also observed higher digestibility of dry matter and organic matter using dry yeast as compared with cottonseed meal.

Changes were not found (P>0.05) for the digestibility of crude protein, ether extract or neutral detergent fiber. However, the total digestible nutrients were higher (P<0.05) for dry yeast and soybean diets compared with the soybean + dry yeast diet (Table 5).

Different effects to dry yeast were observed by Lima et al. (2011), who reported increase in crude protein digestibility, reduction in digestibility of ether extract, no effects on the neutral detergent fiber digestibility and increase in total digestible nutrients of diets with dry yeast in finishing kids. Martins et al. (2000) also reported improvement in the digestibility of crude protein and neutral detergent fiber in heifers fed rations with dry yeast. These differences may be related to the other ingredients of the rations (corn or cassava, hay or corn silage), species, sex and also the physiological stage of animals, which can influence the availability of nutrients.

Conclusions

Dry yeast from sugar cane can be used as protein source for feeding lactating dairy goats because it provides milk quality and production similar to those observed when soybean meal is used.

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