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Performance of dairy females fed dried yeast from sugar cane

Marcia de Oliveira Franco*, Marcos Inácio Marcondes, José Maurício de Souza Campos, Edenio Detmann, Sebastião de Campos Valadares Filho and Denise Ribeiro de Freitas

*Departamento de Zootecnia, Universidade Federal de Viçosa, Avenida PH Rolfs, s/n.º, 36570-000, Viçosa, Minas Gerais, Brazil. *Author for correspondence. E-mail: marciazoo1@yahoo.com.br*

ABSTRACT. This study was performed in order to evaluate the effect of dried yeast from sugar cane when replacing soybean meal in dairy heifers' diets. Twenty-four heifers, with an initial body weight (BW) of 178 kg, were distributed in a completely randomized design. The treatments were four levels of inclusion of dried yeast from sugar cane replacing to soybean meal (0, 33, 67 and 100% on a dry matter (DM) basis). While there was no difference in DM, neutral detergent fiber (NDF), metabolizable energy or roughage intakes, the intakes of non-fiber carbohydrates and concentrate were increased. The crude protein intake decreased according to the dried yeast from sugar cane when replacing soybean meal. The digestibility coefficients of DM and NDF showed no difference. Replacement of soybean meal with dried yeast from sugar cane had no effect on performance, because average daily gain and body measurements studied were similar for all animals and inclusion levels. Soybean meal can be completely replaced with dried yeast from sugar cane in diets for growing dairy heifers without restrictions; this will not affect the intake, digestibility, physical development of animals or metabolization of protein compounds.

Keywords: digestibility, intake, nitrogen balance, soybean meal.

Desempenho de fêmeas leiteiras alimentadas com levedura seca de cana-de-açúcar

RESUMO. Objetivou-se avaliar o efeito da levedura seca de cana-de-açúcar em substituição ao farelo de soja em dietas de novilhas leiteiras. Vinte e quatro novilhas leiteiras com peso médio inicial (BW) de 178 kg foram distribuídas em delineamento inteiramente casualizado. Os tratamentos foram níveis de inclusão de levedura seca de cana-de-açúcar em substituição ao farelo de soja (0, 33, 67 e 100% com base na matéria seca (MS)). Não houve diferença para a ingestão de MS, fibra em detergente neutro (FDN), energia metabolizável e volumoso; entretanto, houve aumento na ingestão de carboidratos não fibrosos e concentrados. A ingestão de proteína bruta diminuiu de acordo com o aumento do nível de levedura em substituição ao farelo de soja. Os coeficientes de digestibilidade da MS e FDN não foram alterados. A substituição do farelo de soja pela levedura não promoveu efeito sobre o desempenho, pois o ganho médio diário e as medidas corporais estudados foram os mesmos para todos os animais, em todos os níveis de inclusão. O farelo de soja pode ser completamente substituído por levedura seca de cana-de-açúcar em dietas para novilhas leiteiras em crescimento, pois não afeta consumo, digestibilidade, desenvolvimento físico dos animais e metabolismo de compostos proteicos.

Palavras-chave: digestibilidade, consumo, balanço nitrogenado, farelo de soja.

Introduction

Animal performance is defined as the voluntary feed intake in sufficient quantities to meet animal maintenance and production requirements. Weight gains above 800 g day^{-1} in heifers are commonly seen in highly technified milk production systems to offset high production costs during the growth phase. However, even with the use of new production technologies, the imbalance between energy and protein still represents one of the major concerns in dairy cattle diets. The unbalanced ratio between energy and protein leads to several problems, such as excessive fat accumulation in the mammary gland rather than the parenchymal tissue, which cause a deleterious effect on production by future dairy cows (National Research Council [NRC], 2001).

Over the years, great efforts have been made regarding the evaluation of different protein sources to be used as a replacement for soybean meal in dairy cow diets. According to Costa, Souza, Saliba and Carneiro (2015), there are many agro-products derived from sugar cane, as an alternative food source, which can be widely used for animal nutrition. In this context, dried yeast from sugar cane has been suggested as a potential substitute for soybean meal, mainly due to its price and chemical composition, which comprises approximately 41%

of CP composed of 80% of amino acids, 12% of nucleic acids and 8% of ammonia nitrogen (Valadares Filho et al., 2010), and is totally degradable in the rumen (Marcondes et al., 2009). Moreover, approximately 7% of the total nitrogen occurs as free amino acids, such as non-protein nitrogen. Dried yeast is currently available at a price that is comparable to soybean meal mainly because non-ruminant nutrition uses this by-product as a source of lysine (Ramos, Birchal, Seara, Pereira & Alvisi, 2011); however, the growing demand for renewable fuels tends to make prices of dried yeast more attractive for use in ruminant nutrition.

There are a few studies on dried yeast inclusion from sugar cane in ruminant diets, some of which have shown that it can be used as a protein source to replace either soybean meal in diets for dairy cows (Freitas et al., 2015), cottonseed meal in diets for heifers (Prado, Martins, Alcalde, Zeoula & Marques, 2000) or cottonseed processing residue for Nellore steers (Messana et al., 2009). Moreover, it has also been reported that dried yeast from sugar cane can replace soybean meal in diets for growing, finishing and lactating goats (Gomes et al., 2012; Gomes, Alcalde, Souza et al., 2014; Lima, Alcalde, Macedo et al., 2011). Therefore, given the lack of information regarding the inclusion of dried yeast from sugar cane, then, this study was developed to evaluate the replacement of soybean meal with dried yeast from sugar cane in the diet of dairy heifers.

Material and methods

The experiment was conducted at the dairy cattle research facility in the Universidade Federal de Viçosa, Brazil. Twenty-four purebred and crossbred Holstein heifers, with an average initial body weight (BW) of 178 kg, were assigned in a completely randomized design, comprisin four treatments and six replications, with 12 Holstein and 12 Holstein × Zebu crossbreds. The care procedures for each heifer were approved by the Animal Ethics Committee of the Universidade Federal de Viçosa, registered under protocol number 26/2013. Heifers were kept in a tie-stall and housed in a covered individual pen with an individual feeder and automatic drinker. Animals were initially weighed and de-wormed prior to the beginning of the experiment.

Heifers were subjected to a period of 28 days of adaptation and an 84-day experimental period (three periods of 28 days each) for the evaluation of animal performance. The heifers were weighed at the beginning of the experiment and then every 28 days. Height at the wither and the hip, heart girth, breast breadth, hip width, body length and average daily gain (ADG) were measured using a graduated scale and a metal measuring tape. Body measurements were obtained with the animals standing with fore- and hindquarters perpendicular on a flat floor.

Experimental diets consisted of four levels of soybean meal (51.0% of CP) replaced with dried yeast from sugar cane (45.5% of CP) in the following proportions: 0, 33, 67 and 100% on a dry matter (DM) basis, with corresponding yeast levels of 0.0, 5.2, 10.3 and 15.5% in the total diets, and 0, 30.3, 60.6 and 90.9% in the concentrate diets. Diets were formulated according to NRC (2001) in order to be isonitrogenous and allow for a gain of 0.80 kg day^{-1}. Urea was used to maintain the diets with the same proportion of protein (Table 1).

Heifers were fed twice a day (50% at 08 hours and 50% at 16 hours) on corn silage *ad libitum* and 1 kg (natural matter basis) of concentrate per heifers. The diets were composed of 83% roughage and 17% concentrate (DM basis). Diets were fed as a total mixed ration. Every day before feeding, the orts of each animal were removed and weighed, with the relevant data recorded. The DM intake was determined by the difference between the weight of feed supplied and unconsumed.

Table 1. Ingredients (g kg^{-1} DM) in the diet and concentrate according to levels of substitution of soybean meal by dried yeast from sugar cane.

Ingredients	Level of substitution[1]			
	0%	33%	67%	100%
Diet				
Corn silage	830	830	830	830
Soybean meal	164	109.33	54.67	0.0
Urea/ammonium sulfate (9:1)	0.0	3.10	6.25	9.40
Dried yeast	0.0	54.67	109.33	164.00
Mineral supplement	9.44	10.02	10.60	11.18
Concentrate diet				
Soybean meal	951.25	629.09	312.00	0.0
Urea/ammonium sulfate (9:1)	0.0	15.88	31.75	47.36
Dried yeast	0.0	303.71	602.42	896.34
Mineral supplement	48.75	51.32	53.83	56.30

[1]Level of replacement of soybean meal.

Source: The authors.

The digestion trial was conducted once during the second experimental period. The external markers, chromic oxide (Cr_2O_3) and titanium dioxide (TiO_2), were supplied over 11 days (five days before initial fecal collections for adaptation). Feces were collected over six consecutive days at intervals of 26 hours (from day 12 to day 17) and at different collection times (08 hours on the first day). Samples were collected directly from the rectum of the heifers, placed in labeled plastic bags and stored at -20°C. At the end of the digestion trial, fecal samples were thawed, weighed and dried in a forced air oven at 55°C for 72 hours, then grounded through a 1 mm screen in a Wiley mill (model 3,

Arthur H. Thomas, Philadelphia, PA, United States). A composite sample was then made for each animal, based on the pre-dried weight of each sample. In the same period, diet ingredients and orts for each heifer were weighed and sampled. At the end of the digestion trial, ort samples were homogenized, with a sub-sample collected, weighed and dried in a forced air oven (model 171A, Fabbe Primar, São Paulo, SP, Brazil) at 55°C for 72 hour, then grounded through a 1 mm screen in a Wiley mill. Similar to the fecal samples, a composite sample was then made for each animal, based on the pre-dried weight of each sample.

During the second experimental period, urine spot samples were collected at feeding times: in the morning (08 hours) and the afternoon (16 hours). The urine was collected during spontaneous urination using pots of polyethylene held below the vagina of the heifer. Samples were mixed in equal amounts to obtain a composite sample of urine. The composite samples were homogenized and filtered, while aliquots (10 mL) were taken and diluted in 40 mL of sulfuric acid 0.036 N. Another aliquot of 50 mL was stored without the addition of sulfuric acid. Samples were frozen for further analysis of urea, total nitrogen, creatinine, uric acid and allantoin. Blood samples were collected approximately four hours after feeding using test tubes with an anticoagulant. The samples were centrifuged at 3,600 g for 20 minutes immediately after collection, while plasma samples were separated, stored in glass containers and frozen at -20°C for further analysis of the N-urea content.

Samples composed of supplied feed and orts were analyzed for DM (method INCT-CA G-003/1), CP (method INCT-CA N-001/1), ether extract (EE; method INCT-CA G-005/1), neutral detergent fibre corrected for ash and protein (NDFap; methods INCT-CA F-002/1, INCT-CA M-002/1 and INCT-CA N-004/1) and acid detergent fiber (ADF; method INCT-CA F-004/1) in line with the standard techniques of the Brazilian National Institute of Science and Technology in Animal Science (INCT-CA) (Detmann et al., 2012). The non-fiber carbohydrates, corrected for ash and protein (NFCap), was calculated according to Detmann and Valadares Filho (2010). The metabolizable energy (ME) was calculated according to Valadares Filho, Marcondes, Chizzotti and Paulino (2010).

Urine was analyzed for urea, total nitrogen, creatinine, uric acid and allantoin. Total daily urine volume was estimated by dividing the daily urinary excretion of creatinine by the observed values of creatinine concentration in urine (Chizzotti, Valadares Filho, Valadares, Chizzotti & Tedeschi, 2008). Daily creatinine excretion (CE; g day^{-1}) was estimated from BW as proposed by Chizzotti et al. (2007). The nitrogen compounds were calculated as the difference between total nitrogen intake and total nitrogen excreted in feces and urine.

A mixed model analysis of variance was used on the results with regard to the yeast levels, genetic group and the interaction between them as fixed effects, with a significance level of 5% probability for type I error. The exclusion of values with Student Residue score > |2| was used whenever necessary to avoid interference from outliers. Statistical analyses were performed using the software SAS 9.4 (Statistical Analysis System. [SAS], 2014).

Results and discussion

Yeast inclusion levels showed a linear effect on CP, NFC and concentrate intakes ($p < 0.05$; Table 2). The CP intake decreased ($p < 0.05$), while the inclusion levels were increased. On the other hand, NFC and concentrate intake increased linearly ($p < 0.05$) according to the greater proportion of yeast in the diet. The genetic group interacted with the yeast inclusion level on concentrate intake. In both cases, intake increased linearly, although the increase was more marked in crossbred dairy heifers than animals from the other group.

The decrease in protein intake at the same time as the inclusion levels of yeast in the diet increased might have been caused by the lower amount of protein in yeast compared to soybean meal (45.5% vs. 51.0% of CP). However, CP values in yeast and soybean meal were different from the predictions and, even though diets contained the same amount of nitrogen, this correction with urea might not have been enough to keep intake constant. By observing the animals receiving the maximum inclusion of yeast, we found that there was no residual concentrate at the bottom of the trough because yeast has a high hygroscopicity, which made it adhere to the particles of silage and, in turn, facilitated ingestion. However, this high hygroscopicity can be inconvenient when it comes to storage and use in areas of high relative humidity.

In an experiment with crossbred heifers, when yeast was used as the only source of protein in substitution for cottonseed meal, Prado et al., (2000) found no significant difference in CP intake.

Table 2. Average intake of dairy heifers according to the levels of substitution of soybean meal by dried yeast from sugar cane and genetic group.

Item	Levels of substitution				Genetic group		CV%	Effect[1]				
	0%	33%	67%	100%	Holstein	Crossbred		LQ	LQ x GG	GG	LL x GG	LL
					kg day^{-1}							
Dry matter	5.42	5.48	5.44	5.48	5.54	5.37	13.5	0.38	0.93	0.30	0.43	0.29
Non-fibrous carbohydrates	2.00	2.13	2.26	2.39	2.22	2.15	14.6	0.66	0.94	0.31	0.44	0.02[2]
Crude protein	0.75	0.72	0.69	0.67	0.70	0.70	9.22	0.98	0.75	0.23	0.14	0.01[3]
Neutral detergent fiber	2.18	2.26	2.22	2.28	2.24	2.20	15.7	0.45	0.73	0.40	0.50	0.72
Concentrate	0.79	0.80	0.80	0.81	0.799	0.804	1.4	0.61	0.27	0.22	0.01[4]	0.02
Forage	4.62	4.64	4.69	4.67	4.74	4.57	15.8	0.66	0.94	0.31	0.45	0.32
Ether extract	0.118	0.122	0.129	0.125	0.122	0.123	13.3	0.22	0.87	0.93	0.88	0.33
					%BW							
Dry matter	2.40	2.51	2.43	2.44	2.37	2.45	20.3	0.58	0.61	0.71	0.87	0.78
Neutral detergent fiber	0.94	0.99	0.98	0.97	0.95	1.00	20.1	0.43	0.70	0.64	0.83	0.85
					mcal day^{-1}							
Metabolizable energy	13.09	13.12	13.15	13.19	13.96	13.41	13.8	0.27	0.88	0.36	0.44	0.94

[1]LQ, quadratic effect of dried yeast; LQ x GG, genetic group effect on the quadratic effect of yeast; GG, genetic group effect on the average; LL x GG, genetic group effect on the linear effect of yeast; LL, linear effect of yeast. Regression equations: [2]$Y = 2.004 + 0.382 \times X$. [3]$Y = 0.748 - 0.084 \times X$. [4]Crossbred: $Y = 0.788 + 0.034 \times X$; Holstein: $Y = 0.788 + 0.015 \times X$.
Source: The authors.

Additionally, Gomes, Alcalde, Lima et al. (2014) found that yeast is a good alternative protein source to replace soybean meal in diets for lactating goats; it also does not affect the DM and nutrient intake, nor the nutritive value of diets. Otherwise, Lima, Alcalde, Freitas et al. (2012) found lower intakes of DM and CP for goats fed dried yeast instead of soybean meal. More results are, therefore, needed to qualify the effect of including dried yeast from sugar cane in dairy heifers' diets. The greater NFC intake occurred because yeast had a higher proportion of this nutrient in relation to soybean meal (46.9% vs. 16.0% of NFC).

When dairy heifers from different genetic groups are kept together in an experiment, the genetic group needs to be considered. This is because the concentrate intake has been shown to have been affected by interaction between the yeast level and the genetic group. According to Van Soest (1994), characteristics of animal physiology, such as preference, can play an important role in the choice and selection of feeds, which are based on taste and color. In this case, along with these factors, the difference between genetic groups, which indicated differences in concentrate intake, was also noteworthy. When animals are subjected to the same diet and feeding management, it is expected that differences in intake and performance will be linked to factors inherent in the animals. Part of the variation in the ability of ruminants to consume feeds is based on genetics; however, the magnitude of its influence is hard to establish (Weston, 1982). It was possible to observe that crossbred animals showed higher selectivity, which allowed them to ingest more concentrate compared to female Holsteins (Table 2).

Regarding the intake of other nutrients, there was no significant effect ($p > 0.05$) for DM, for DM as a percentage of BW and NDF, and for NDF as a percentage of BW, EE, ME and roughage according to the inclusion levels of yeast and the genetic group (Table 2).

Yeast inclusion levels and the genetic group did not affect ingestion of other nutrients, demonstrating that yeast inclusion overall did not cause deleterious effects on intake. The DM intake is the main nutritional factor responsible for variations in animal production (Crampton, Donefer & Lloydal, 1960), followed by the transformation of digestible nutrients of the diet in animal product. From the voluntary DM intake, we can determine the amount of nutrients ingested and obtain estimates of the amount of animal product generated (Van Soest, 1994). Regardless of treatment, then, DM intake was the same and also made the ingestion of the other dietary nutrients similar. Observing animals during the experiment, we found a great acceptance of diets, even in the treatment with the maximum inclusion of yeast, which shows that yeast is a palatable food. Besides, ruminal distension and fill are directly affected by the contribution of the cell wall in the diet, while the fermentation rate depends on intrinsic characteristics of the carbohydrates; therefore, the quality of ingredients utilized in the formulation of the diets seems not to have had a large influence on intake.

The digestibility of DM and NDF showed no difference ($p > 0.05$; Table 3), while interaction between treatment and animal breed group affected ME ($p < 0.05$). When studied separately, however, the factors showed no significance and, as such, this interaction was not considered.

Yeast had a linear effect on the digestibility of CP, NFC and EE ($p < 0.05$) (Table 3). The

digestible CP of crossbreds reduced as yeast was increased in the diet, but increased at the maximum level of inclusion. Meanwhile, for the Holsteins' CP, digestibility decreased linearly according to the inclusion of yeast. The NFC digestibility showed interaction with the linear effect of treatment and difference between genetic groups, while there was an antagonistic behavior between NFC digestibility of crossbred and Holstein females: the first increased linearly and the latter reduced. We can observe that, when the effect of genetic variation among heifers was not considered, the CP and NFC digestibility was not affected by the addition of yeast to the diets (693 and 762 g kg^{-1} on average, respectively). Digestibility of EE, in turn, decreased linearly as the inclusion yeast levels were elevated.

It is rather difficult to measure the dietary protein digestion values, not only because of the difficulty to have animals prepared with abomasal, duodenal or ileal cannulas, but also because microbial and endogenous nitrogen is added to the protein fraction of the diet (Orskov, 1982). Even if the fractions that reach the intestine are estimated, the hypothesis of non-variation of endogenous N would apply. Thus, based on these results, we analyzed the data by isolating the effect of the genetic group as a random effect in the model, such that it was possible to study the effect of yeast isolated. Lima, Alcalde, Gomes et al. (2012) also found no significant difference in digestibilities when soybean meal was replaced by yeast in diets for goats. The behavior presented by NFC digestibility once more demonstrates the need to study the genetic variation of animals.

The CP digestibility values, which were reported by Ezequiel, Sampaio, Seixas and Oliveira (2000) when the effect of genetic variation between animals was not considered, corroborate those found in the present study, since there was also no difference found with regards to the replacement of soybean meal with dried yeast from sugar cane in the diet for sheep.

Replacement of soybean meal with dried yeast from sugar cane had no effect on ADG and the body measures studied ($p > 0.05$; Table 4). As for weight gain in relation to height at the hip, the results differed according to the genetic group ($p < 0.05$).

Animals gained weight and grew similarly with the different inclusion levels of yeast and genetic groups.

Table 3. Average of apparent digestibility (g kg^{-1}) as a function of the substitution levels of soybean meal by dried yeast from sugar cane and genetic group.

Item	Levels of substitution				Genetic group		CV%	Effect[1]				
	0%	33%	67%	100%	Holstein	Crossbred		LQ	LQ x GG	GG	LL x GG	LL
Dry matter	641.1	642.3	641.8	643.1	638.9	637.2	5.83	0.27	0.92	0.51	0.27	0.94
Crude protein	717.9	691.1	672.5	689.6	694.5	687.0	3.35	0.02	0.01	0.90	0.01[2]	0.04
Neutral detergent fiber	615.7	616.6	615.2	616.1	637.8	607.1	14.06	0.81	0.73	0.46	0.22	0.06
Ether extract	847.2	865.4	883.7	901.9	868.5	866.9	4.30	0.13	0.89	0.17	0.22	0.02[3]
Non-fiber carbohydrate	784.4	843.4	680.8	739.9	763.0	759.2	9.08	0.87	0.78	0.01	0.01[4]	0.04
Metabolizable energy, Mcal	2432	2441	2423	2430	2505.5	2487.4	3.91	0.49	0.98	0.12	0.02	0.75

[1]LQ, quadratic effect of dried yeast; LQ x GG, genetic group effect on the quadratic effect of yeast; GG, genetic group effect on the average; LL x GG, genetic group effect on the linear effect of yeast; LL, linear effect of yeast. Regression equations: [2]Crossbred: $Y = 71.035 - 25.013 \times X + 24.776 \times X^2$; Holstein: $Y = 71.035 - 1.809 \times X - 3.463 \times X^2$. [3]$Y = 84.716 + 5.478 \times X$. [4]Crossbred: $Y = 72.869 + 5.903 \times X$; Holstein: $Y = 87.033 - 22.497 \times X$.

Source: The authors.

Table 4. Average daily gain (kg day^{-1}) and absolute (cm/day) and relative (kg cm^{-1}) daily body increases as a function of the substitution levels of soybean meal by dried yeast from sugar cane and genetic group.

Item	Levels of substitution				Genetic group		CV%	Effect[1]				
	0%	33%	67%	100%	Holstein	Crossbred		LQ	LQ x GG	GG	LL x GG	LL
Average daily gain	0.84	0.86	0.86	0.85	0.81	0.96	16.9	0.78	0.60	0.10	0.63	0.11
Absolute growth												
Heart girth	0.18	0.19	0.18	0.19	0.17	0.21	21.7	0.54	0.69	0.15	0.50	0.11
Body length	0.13	0.14	0.15	0.15	0.13	0.14	31.1	0.88	0.45	0.25	0.62	0.36
Hip height	0.09	0.09	0.10	0.10	0.10	0.08	25.5	0.91	0.63	0.09	0.41	0.16
Wither height	0.09	0.09	0.10	0.09	0.10	0.08	25.5	0.49	0.45	0.26	0.55	0.13
Hip width	0.06	0.06	0.07	0.06	0.05	0.06	34.3	0.60	0.39	0.31	0.30	0.17
Breast breadth	0.07	0.08	0.07	0.08	0.06	0.07	23.9	0.48	0.36	0.18	0.32	0.19
Relative growth												
Heart girth	4.60	4.64	4.66	4.65	4.90	4.69	14.6	0.68	0.93	0.83	0.54	0.90
Body length	6.80	6.80	6.81	6.86	6.52	7.52	26.8	0.56	0.91	0.58	0.84	0.13
Hip height	10.95	10.67	11.12	11.71	8.43	12.65	25.0	0.54	0.81	0.01	0.85	0.06
Wither height	9.52	9.50	9.50	9.53	7.91	12.23	27.3	0.53	0.58	0.09	0.84	0.42
Hip width	16.63	16.61	16.65	16.64	18.17	16.68	32.3	1.00	0.48	0.54	0.71	0.80
Breast breadth	13.8	14.0	14.3	14.1	13.95	14.03	17.1	0.98	0.02	0.93	0.86	0.37

[1]LQ, quadratic effect of dried yeast; LQ x GG, genetic group effect on the quadratic effect of yeast; GG, genetic group effect on the average; LL x GG, genetic group effect on the linear effect of yeast; LL, linear effect of yeast.

Source: : The authors.

The DM intake is the main nutritional factor responsible for variations in animal production (Crampton et al., 1960) and, since there were no differences in DM intake, performance was also not affected by inclusion levels. Otherwise, according to Campos, Pereira, Ribeiro, Santos and Valadares Filho (2014), increased levels of dried yeast in diets for Nellore bulls resulted in reduced intake and ADG.

As in the present study, Prado et al., (2000) found no differences in the ADG of crossbred heifers that were fed dried yeast from sugar cane instead of cottonseed meal. On the other hand, Aguiar et al. (2007) found that the replacement of corn and soybean meal with yeast in diets for sheep negatively affected animal performance in general. Additionally, Freitas, Alcalde, Lima, Macedo et al. (2011) found that dried yeast can be included in diets for goat kids without changing the quantitative characteristics of the carcass and quality characteristics of the loin and shoulder.

Body measurements, when assessed alone, do not indicate whether the body growth and physiological maturation of heifers are appropriate; however, if used along with other zootechnical parameters, they can help to evaluate the development of these animals. Furthermore, it is important to monitor animal development, since diet and growth rate have a direct effect on age at first calving as well as on productivity per day in the life of the herd. Based on these parameters, we can see that there were no significant differences in the growth pattern of dairy females fed dry yeast instead of soybean meal. Thus, the growth velocity of animals is consistent with the ADG, regardless of the yeast inclusion level, because weight gain in relation to body measures was equal between treatments.

Compared to height at the hip, the results obtained for weight gain demonstrate the importance of separately evaluating each genetic degree. Crossbred animals had a higher weight gain in relation to height at the hip, with an average 12.65 kg cm^{-1}, while female Holsteins showed a lower value (8.43 kg cm^{-1}; Table 4). This effect can be explained by the greater concentrate intake of crossbred animals (Table 2), which elevated body growth in this variable, since the other intakes and digestibilities were similar between the genetic groups.

Yeast inclusion levels had no effect ($p > 0.05$) on urinary volume, plasma urea nitrogen and allantoin (Table 5). On the other hand, urea concentration urine decreased linealy ($p < 0.05$), whereas uric acid in urine showed a quadratic effect ($p < 0.05$) as the yeast levels increased. For the other parameters studied, such as purine derivatives, microbial nitrogen and microbial efficiency, no significant effect ($p > 0.05$) was observed as yeast was added.

The lack of any significant effect on urinary volume, plasma urea nitrogen and allantoin according to the yeast inclusion levels demonstrates that the utilization of these compounds remained the same because degradation and utilization of protein compounds in both sources are equal. These results are in line with Rufino et al. (2013), who found no difference in these variables when soybean meal was completely replaced with dried yeast in lambs' diets.

Urea is the primary means of N excretion in mammals, while the concentration of blood plasma urea is well-known for reflecting inefficiency in the use of dietary CP (Broderick & Clayton, 1997). Plasma urea nitrogen levels seem not to have reflected variations in the protein metabolism because they remained constant, even at the maximum level of replacing soybean meal with dry yeast (Table 5).

Table 5. Urinary volume (L day^{-1}), nitrogen compounds, microbial nitrogen (g day^{-1}) and microbial efficiency (g CP kg^{-1} TDN) as a function of the substitution levels of soybean meal by dried yeast from sugar cane and genetic group.

Item	Levels of substitution				Genetic group		CV%	Effect[1]				
	0%	33%	67%	100%	Holstein	Crossbred		LQ	LQ x GG	GG	LL x GG	LL
Urinary volume	11.8	12.1	12.3	12.0	12.65	11.56	14.8	0.79	0.79	0.06	0.28	0.86
					mg dL^{-1}							
Urea in urine	842.03	776.8	711.5	646.3	792.4	713.7	19.9	0.62	0.06	0.65	0.19	0.02[2]
Plasma urea nitrogen	17.7	18.0	18.2	17.9	18.7	17.2	31.9	0.15	0.61	0.68	0.97	0.18
					mmol day^{-1}							
Uric acid in urine	0.42	0.60	0.63	0.53	0.57	0.55	23.1	0.02[3]	0.09	0.92	0.93	0.01
Allantoin	111.6	112.0	112.1	111.9	113.3	110.9	12.1	0.60	0.83	0.14	0.13	0.56
Purine derivatives	112.0	112.3	112.7	112.5	113.8	111.5	12.1	0.61	0.83	0.14	0.13	0.55
					Efficiency of microbial synthesis							
Microbial nitrogen	73.3	73.5	73.9	73.8	74.5	73.4	12.5	0.30	0.42	0.13	0.17	0.68
Microbial efficiency	126.7	127.1	127.2	127.0	127.5	126.8	8.8	0.45	0.93	0.63	0.47	0.20

[1]LQ, quadratic effect of dried yeast; LQ x GG, genetic group effect on the quadratic effect of yeast; GG, genetic group effect on the average; LL x GG, genetic group effect on the linear effect of yeast; LL, linear effect of yeast. Regression equations: [2]$Y = 842.06 - 195.73 \times X$. [3]$Y = 0.420 + 0.735 \times X - 0.621 \times X^2$.

Source: : The authors.

Although plasma urea nitrogen has a high and positive correlation with dietary CP contents (Broderick & Clayton, 1997), Van Soest (1994) reported that the amount of recycled urea is relatively independent from dietary nutrients, provided that the size of the urea pool in the bloodstream is under physiological homeostatic control, which tends to be constant. Thus, it is possible that the urea pool in the plasma was not affected by dietary nitrogen.

The ammonia absorbed by the digestive tract is converted into urea by the liver and excreted in the urine or transferred to the intestine, until it is degraded by microorganisms. For a given diet, the amount of urea recycled to the rumen, either through the saliva or through the rumen wall, is directly related to N intake and the degradability of the dietary N (Obara, Dellow & Nolan, 1991). Thus, the CP intake reduced as the yeast in the diet increased (Table 2), as well as reduced the amount of protein substrate to be metabolized in the rumen and consequently reduced the loss of urea in urine, even though digestibility was unchanged with the inclusion levels. According to the results found in the literature, yeast inclusion has no effect on urea excretion in the urine in young goats (Freitas, Alcalde, Lima, Zeoula et al., 2011), sheep (Ezequiel et al., 2000) and Holstein calves (Sampaio, Vieira & Brito, 2000).

The uric acid content in urine had a quadratic behavior, increasing and then reducing again in the treatment involving the maximum inclusion of yeast. This can be explained not only by the reduced protein intake, but also by the quadratic effect on protein digestibility in crossbreds when the genetic group was still being counted.

The microbial protein synthesis depends on the availability of carbohydrates, while N in the rumen and microbial growth is maximized by the synchronization between the availability of fermentable energy and the N degradable in the rumen (NRC, 2001). Thus, we can infer that, in the present experiment, there was no limitation in microbial growth for any of the diets tested, because regardless of the inclusion level, microbial efficiency in the use of N-based compounds and energy compounds was similar between the sources of protein utilized in the diets for growing dairy females.

Conclusion

Soybean meal can be completely replaced with dried yeast from sugar cane in diets for growing dairy heifers without restrictions; nor will it affect the intake, digestibility, metabolization of protein compounds and physical development of animals.

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