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Economic viability of feeding dairy cows on diets containing different levels of soybean oil

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ABSTRACT - The objective of this study was to evaluate the economic viability of feeding dairy cows with diets containing different levels of soybean oil. Cows were fed diets based on tropical forage (*Pennisetum purpureum* Schum) supplemented with different levels of soybean oil (0.0, 1.5, 3.0, and 4.5% of diet DM). The calculations were made considering the prices of the dietary ingredients and the daily consumption of each dietary treatment. The milk quality-based payment was estimated on the bonus paid for milk fat and protein contents according to two systems used by companies of the dairy sector. The economic benefit was calculated as the difference between the income obtained from milk sale and the cost associated with animal feeding. The MOP scenario analysis (most likely - optimistic - pessimistic) was performed on the basis of the real scenario and variations in milk price and inputs observed in season and off-season periods over the years under study. The diet with 1.5% soybean oil had higher economic benefit when compared with those containing 3.0 and 4.5% soybean oil. All the dietary soybean oil levels would result in bonuses for milk protein content (higher than 3.03 and 3.21). Only the control diet showed a positive economic balance. The bonuses paid for milk protein content were insufficient to cover the additional costs associated with the inclusion of soybean oil in the diets, resulting in negative balances for the treatments with 1.5; 3.0 and 4.5% soybean oil, demonstrating the economic non-viability of supplementing diets of lactating cows with soybean oil.

Key Words: milk quality, nutrition, production cost

Introduction

The inclusion of lipids in the diet of dairy cows is a common practice in intensive milk production systems. The main objective of this dietary strategy is to increase dietary energy density in order to meet the requirements of high-producing cows and reduce the proportion of concentrates rich in rapidly degrading carbohydrates, which can cause ruminal acidosis, affecting animal performance and health (Ribeiro et al., 2007). Studies conducted over the last ten years have also shown that dietary supplementation with plant oils promotes a positive alteration in the milk fatty acid profile as a consequence of the reduction in medium-chain saturated fatty acids and increased concentrations of oleic acid and conjugated linoleic acids (CLA) in milk fat (Gama, 2010).

Ruminant milk fat has been considered a risk factor for coronary heart diseases due to its high medium-chain saturated fatty acid content. Thus, recent studies have focused on reducing the milk fat content of these saturated fatty acids and increasing the mono and polyunsaturated ones such as oleic acid, *cis*-9, *trans*-11 CLA and vaccenic acid (Palmquist, 2010).

The manipulation of milk components through nutrition aims to meet the demand of the consumers for special milk and other dairy products, once an increasing number of people have become aware of the link between nutrition and health. The majority of studies involving dietary supplementation with lipid sources have been conducted with dairy cows fed diets based either on conserved forages such as corn silage and legume hay, or temperate forages in grazing systems. On the other hand, tropical forage-based studies are limited and the production costs are seldom reported. The objective of this study was to evaluate the economic viability of feeding dairy cows with diets based on tropical forage supplemented with different levels of soybean oil.

Material and Methods

The data used in the present study were obtained from an experiment conducted at the Experimental Station José

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Henrique Bruschi (Embrapa Dairy Cattle, Zona da Mata region, state of Minas Gerais, Brazil). In this experiment, the authors evaluated the performance and milk composition of dairy cows fed diets based on chopped (60±30 days of growth) tropical forage (*Pennisetum purpureum* Schum), supplemented with increasing levels of soybean oil (0; 1.5; 3.0 and 4.5% of diet dry matter). Diets were formulated to meet or exceed the requirements established by the NRC (2001) (Table 1).

Twelve multiparous Holstein × Gir cows of genetic composition ranging from 3/4 to 15/16 Holstein, averaging 90±25 days in milk and producing 17.6±5.5 kg of milk/day were housed in free stall barns and received the dietary treatments (levels of soybean oil in the diet) in a triplicated 4 × 4 latin square design composed of 15-day experimental periods (10 days for diet adaptation and five for data collection).

The soybean oil was mixed weekly with the concentrates in order to minimize its lipid peroxidation. Diets were fed once a day, before morning milking, as a Total Mixed Ration (TMR). The dry matter (DM) intake was determined individually using electronic gates (calan-gates, American Calan Inc.®, Northewood, NH, EUA); the amount of dry matter was adjusted daily to enable for 10% of leftovers. Samples of TMR, leftovers, forage and concentrates were collected throughout the experiment for analysis of feed composition.

The animals were milked twice a day (6h00 and 14h00) and composite samples of milk were analyzed for protein, fat and solid contents (Bentley 2000, Bentley Instruments®). Milk yield was recorded daily and the animals were weighed in the beginning and at the end of each treatment period. The 3.5% fat-corrected milk yield was calculated through the following equation: (0.432 +0.1625 × % milk fat) × milk yield (Sklan et al., 1992).

The economic evaluation performed by using the computational system Custo Dietas (Lage et al., 2011) considered the income obtained from milk sale (R$ 0.75/kg) and the feed costs for each dietary treatment, with all the values estimated from the market in August 2010. The economic benefit was calculated by the difference between the income from milk sale and the costs associated with animal feeding.

A simulation was performed considering milk quality-based payment systems adopted by two companies of the dairy sector in Brazil. According to the criterion reported by Cunha et al. (2010), bonuses were paid when milk fat and protein content were higher than 3.30 and 3.03%, respectively. Thus, bonuses of R$ 0.00511 and R$ 0.01010/kg of milk were paid for milk containing 3.30 and 3.40% of fat, respectively. Similarly, milk protein contents of 3.03 to 3.09% also received a bonus of R$ 0.00713/kg of milk, whereas contents below 3.0% were paid no bonus. Another simulation was performed by following the criteria reported by Gimenes & Ponchio (2006), in which milk protein contents varying from 3.21 to 3.30% and from 3.41 to 3.50 were paid bonuses of R$ 0.00642 and R$ 0.01937/kg of milk, respectively. Regarding the milk fat, only the contents above 3.60% were paid bonuses of R$ 0.0065/kg of milk.

The most likely-optimistic-pessimistic scenarios (MOP, Gropelli & Nikbakht, 2002) analysis was also performed using the available dataset. A real scenario was considered for this analysis, which was based on prices practiced on the market by the time of the study completion. Both the pessimistic and optimistic scenarios were simulated. For the optimistic one, the following options were considered: a) average milk price and low input prices; b) high milk price and low input prices; c) high milk price and average input prices. For the pessimistic scenario, the following situations were considered: d) average milk price and high

Table 1 - Ingredients and chemical composition of diets containing different levels of soybean oil on a dry matter basis

Ingredients	Level of addition of soybean oil (% of diet dry matter)			
	0%	1.5%	3.0%	4.5%
Elephant grass	46.0	46.0	46.0	46.0
Corn meal	17.0	16.3	15.1	14.4
Soybean meal	19.0	19.0	19.8	19.6
Citrus pulp	17.0	16.3	15.1	14.4
Vitamin-mineral mixture	1.0	1.0	1.0	1.0
Soybean oil	0.0	1.5	3.0	4.5
Chemical composition of the diet				
Crude protein (%)	14.5	14.4	14.5	14.4
Neutral detergent fiber (%)	43.0	42.8	42.6	42.3
Ether extract (%)	2.7	4.1	5.6	7.0
Net energy of lactation (Mcal/kg)	1.44	1.50	1.56	1.62

Roughage:concentrate ratio = 46:54.

input prices; e) low milk price and average input prices; f) low milk price and high input prices.

The following alternative scenarios were also taken into consideration: g) high milk and inputs prices; h) low milk and inputs prices. These scenarios were included because it was not possible to predict if they would be either pessimistic or optimistic when the simulation was performed. As for the high values of inputs, the increase in the prices of the most representative dietary ingredients were considered; thus, soybean meal, corn and soybean oil prices were increased by 4.0; 22.50; 16.19%, respectively, which occurred during the off-season of the previous year. As for the low input prices, reductions of 20.0; 17.50; and 13.81% were found, respectively, in relation to the prices practiced in the real scenario. In relation to milk, the prices were R$ 0.75; R$ 0.76 (R$ 0.75 + 1.73%) and R$0.74 (R$ 0.75 – 1.73%)/kg of milk in the real, optimistic and pessimistic scenarios, respectively. The percentages of increase and decrease in prices were surveyed on the basis of the estimates obtained in the previous year during the off-season and crop periods (2010-2011), respectively.

Results and Discussion

Milk yield, 3.5% fat-corrected milk yield, dry matter intake and milk protein yield were unchanged (P>0.05), whereas milk fat yield (P<0.05), milk protein content (P<0.05) and milk fat content (P<0.01) were affected by the dietary treatments.

The diet containing 1.5% of soybean oil had the highest income from milk sale per cow per day, considered the most economically attractive dietary treatment because of the lower feed cost and higher economic benefit as compared with diets containing 3.0 and 4.5% soybean oil (Table 2).

In this study, two simulations on milk quality-based payments were made. When the criteria of Cunha et al. (2010) were used, all the dietary soybean oil levels would result in bonuses for milk protein content (higher than 3.03%) (Table 3). On the other hand, only the control diet would result in bonus for milk fat content (higher than 3.30%). All the dietary treatments would result in similar bonuses for the total volume of milk. Vercesi Filho et al. (2000) reported that the economic weight of milk with 3.1% of fat was positive;

Table 2 - Productive and economic data obtained from a study in which cows were fed diets containing different levels of soybean oil

Variable	Level of soybean oil in the diet (% DM)				CV (%)	P value	
	0.0	1.5	3.0	4.5		Linear	Quadratic
Intake (kg DM/d)	17.50	17.50	17.20	1.70	9.5	0.9691	0.4816
Milk yield (kg/cow/day)	17.80	18.70	18.20	18.20	5.7	0.8565	0.5682
3.5% fat corrected milk yield (kg/cow/day)	17.40	17.60	16.80	16.40	7.0	0.1389	0.7989
Milk protein yield (kg/cow/day)	0.58	0.61	0.60	0.62	5.0	0.5048	0.9800
Milk protein content (%)[1]	3.23	3.25	3.30	3.46	3.8	0.0298	0.2731
Milk fat yield (kg/cow/day)[2]	0.60	0.59	0.55	0.52	9.8	0.0326	0.9452
Milk fat content (%)[3]	3.36	3.11	2.99	2.84	7.4	0.0004	0.5931
Income from milk sale/cow/day (R$)	13.35	14.02	13.65	13.65			
Feed cost/cow/day (R$)	6.47	6.90	7.26	7.90			
Economic benefit/cow/day (R$)	6.88	7.12	6.39	5.75			

L and Q - linear and quadratic effects, respectively.
[1] $\hat{Y} = 0.07206X + 3.13167$ ($r^2 = 0.910$).
[2] $\hat{Y} = -0.03145X + 0.63703$ ($r^2 = 0.932$).
[3] $\hat{Y} = -0.17277X + 3.49724$ ($r^2 = 0.891$).

Table 3 - Feed cost, bonuses paid for milk protein and milk fat contents, income, economic benefit per kg of milk and net gain in each dietary treatment

Item	Level of soybean oil in the diet (% DM)			
	0	1.5	3.0	4.5
A - Feed cost of milk (R$/kg)	0.3635	0.3690	0.3989	0.4341
B - Bonus paid of milk (R$/kg)	0.75000	0.75000	0.75000	0.75000
C - Bonus paid for milk protein content (R$/kg of milk)[1]	0.01755	0.01914	0.02393	0.03191
D - Bonus paid for milk fat content (R$/kg of milk)[1]	0.00511	0.00000	0.00000	0.00000
E - Income (R$/kg) (B+C+D)	0.77266	0.76914	0.77393	0.78191
F - Economic benefit (R$/kg) (E-A)	0.40916	0.40014	0.37503	0.34781
G - Milk yield (kg/day)	17.8000	18.7000	18.2000	18.20000
H - Net gain (R$/day)1 (F × G)	7.28305	7.48262	6.82555	6.33014

[1] Criterion used by Cunha et al. (2010).

indicating that the increase in milk yield implies economic gain for the farmer. However, the economic weight of milk with a milk fat content above 3.1% was negative, showing that the increase in these characteristics generates economic loss. This is probably due to the low pay per fat content policy adopted by the companies of the dairy sector and the higher cost with feeding, since, according to Ribeiro (2009), fat yield demands a greater amount of energy than that of other milk components.

The control treatment had the lowest feed cost per kg of milk (R$ 0.3635), followed by the diet containing 1.5% of soybean oil (R$ 0.3690). There was a variation of R$ 0.0706 per kg of milk (from R$ 0.3635 to R$ 0.4341) between the dietary treatments; a remarkable value within the feeding item, which made the production costs onerous. These costs are usually the major expenses in milk production systems, presenting variations of 55.04% (Lopes et al., 2008) to 66.49% (Lopes et al., 2005) of total costs. Exemplifying, if a R$ 0.0706/kg/milk value was considered, a hypothetical herd of 50 cows with an average yield of 18 kg/day would produce an income of R$ 1,906.20 (0.0706/kg × 50 cows × 18 kg/animal × 30 days) in a month. Such value is very attractive economically.

The combination of the bonuses paid for the volume of milk, milk protein content and milk fat content are extremely important. The economic benefits per kg of milk varied from R$ 0.34781 to R$ 0.40916 between the dietary treatments, a difference of R$ 0.06135 per kg of milk (Table 3).

The bonuses paid for milk protein content were insufficient to offset the additional costs associated with the addition of soybean oil to the diets evaluated in this study, resulting in negative balances for all the dietary treatments containing soybean oil. Only the control diet showed a positive balance (Table 4).

The simulation performed on the basis of the criteria used by Gimenes & Ponchio (2006) also resulted in bonuses for milk protein content in all dietary treatments (Table 5). However, no treatment resulted in bonus for milk fat content. In this milk quality-payment system, the income variation between the dietary treatments was lower (R$ 0.7693 to R$ 0.7564). The economic benefits per kg of milk varied from R$ 0.3864 to R$ 0.3193 between the dietary treatments, a difference of R$ 0.0129. The economic benefit decreased as the level of soybean oil in the diet increased from 0 to 4.5%, which is consistent with the high cost associated with the soybean oil addition to the diets. While designing a payment system for an enterprise using a payment policy per milk quality, the authors obtained an annual positive balance of R$ 2,150,000.00. They suggested that the values achieved could be reverted into financial incentives for the farmers. Thus, the improvement in milk quality seems to be an interesting tool for both farmers and dairy companies in milk quality-based payment systems.

As observed in the simulation based on the criteria of Cunha et al. (2010), the bonuses paid for milk fat and protein content were also insufficient to offset the additional

Table 4 - Economic viability of feeding dairy cows diets containing different levels of soybean oil, considering the bonuses paid for milk protein and milk fat content

Item	Level of soybean oil in the diet (% DM)			
	0%	1.5%	3.0%	4.5%
A - Additional cost associated with soybean oil feeding (R$/animal/day)	0.000	0.4300	0.7900	1.4300
B - Bonus paid for milk protein content (R$)[1]	0.3123	0.3579	0.4355	0.5807
C - Bonus paid for milk fat content (R$)[2]	0.0909	0.0000	0.0000	0.0000
D - Balance = (B + C) – A (R$)	0.4032	-0.0721	-0.3545	-0.8493
E - Is it economically viable?	Yes	No	No	No

[1] Bonuses paid for milk protein content/kg of milk × milk yield.
[2] Bonuses paid for milk fat content/kg of milk × milk yield according to the criteria used by Cunha et al. (2010).

Table 5 - Feed costs, bonuses paid for milk fat and protein content, income, economic benefit per kg of milk and net gain in each dietary treatment

Item	Level of soybean oil in the diet (% DM)			
	0%	1.5%	3.0%	4.5%
A - Feed cost per kg of milk (R$)	0.3700	0.3900	0.4200	0.4500
B - Payment and bonuses /kg of milk (R$)	0.7500	0.7500	0.7500	0.7500
C - Bonus paid for milk protein content (R$/kg of milk)[1]	0.00642	0.00642	0.00642	0.01937
D - Bonus paid for milk fat content (R$/kg of milk)[1]	0.0000	0.0000	0.0000	0.0000
E - Income (R$/kg of milk) (B+C+D)	0.7564	0.7564	0.7564	0.7693
F - Economic benefit (R$/kg of milk) (E-A)	0.3864	0.3664	0.3364	0.3193
G - Milk yield (kg/day)	17.800	18.700	18.200	18.200
H - Net gain (R$/day) (F × G)	6.8782	6.8520	6.1228	5.8125

[1] Criteria used by Gimenes & Ponchio (2006).

costs associated with the addition of soybean oil to the diets when the criteria of Gimenes & Ponchio (2006) was adopted. Again, only the control diet showed positive balance (Table 6).

In the comparison of the control diet with the diet containing 4.5% of soybean oil, the contents of *cis*-9, *trans*-11 CLA and oleic acid increased by 360%, while vaccenic acid rose by 470%. It must be stressed that these fatty acids have been shown to possess health-enhancing properties in both animal and clinical studies. In addition, a linear reduction ($P<0.05$) in milk fat medium-chain saturated fatty acids was observed, which is desirable due to their positive association with cardiovascular heart disease risk. It is likely that there are market niches for consumers willing to pay extra money for dairy products naturally enriched with fatty acids beneficial to health, which is part of an emerging market of health-promoting foods (the so-called functional foods). In this scenario, the use of more expensive dietary ingredients such as soybean oil in the diet of dairy cows could be economically viable.

The results herein presented are based on a real scenario, which included the prices practiced in the market by the time the study was conducted. In order to investigate what situation would be expected in crop and off-season periods considering oscillations in milk and inputs prices, the MOP analysis proposed by Gropelli & Nikbakht (2002) was conducted. It was observed that the control diet showed the best economic viability in all the above-mentioned scenarios. In the optimist scenario (i.e., high milk price and low input price), only the diet containing 1.5% of soybean oil resulted in a slight positive balance. In the other scenarios, the bonuses paid for milk fat and protein content were insufficient to offset the additional costs associated with the addition of soybean oil to the diets (Table 7).

Apart from its effect on fat and milk protein contents, the supplementation of diets for dairy cows with vegetable oils positively alters the milk fatty acid composition as a result of an increased concentration of oleic acid and conjugated linoleic acid (CLA) in milk fat (Gama, 2010). Nowadays, milk and other dairy products naturally enriched with CLA and omega-3 fatty acids are available for the consumers in some countries (Dónega, 2010). However, there are no dairy companies in Brazil paying bonuses for milk with enhanced nutraceutical properties. Similar to the payment of bonuses based on milk quality (somatic cell count, total bacterial count, milk protein and milk fat content) currently practiced by some dairy companies in Brazil and other countries, the payment of a bonus for dairy farmers who deliver milk potentially beneficial for human health has been suggested. The dairy industry, in turn, could share the higher economic return obtained from milk sale with the dairy farmers.

Feeding costs represented 57.87% of the income obtained from the milk sale in the dietary treatment with 4.5% of soybean oil. This value shows the importance of this item in milk yield and the importance of minimizing costs associated with cow feeding in dairy farms. The treatments with the inclusion of 1.5 and 3.0% of soybean oil achieved 49.21 and 53.18% of impact on the milk sale income, respectively, and the control treatment, without the inclusion of soybean oil, reached 48.46%. The estimations of this index are justified, since neither estimation of the production costs nor analyses of profitability were done in this study. According to Lopes et al. (2011), in a production system in which the control of costs is not adopted due to the need for a long data collection period (minimum 12 months), in order to have more precise information, which could actively aid the decision- making process, an alternative is to calculate the ratio of the item that composes the effective operational cost with the milk income, that is, how much of the milk income the farmer spends every month on feeding, labor, health, etc. Such calculations give us the notion of the situation of the dairy cattle at that moment. These authors pointed out that this ratio can vary whenever an alteration in the milk price and in the inputs which compose the effective operational cost occurs. They further suggest that these indexes can be taken as a reference, especially in production systems that present economic viability (for those farmers who still do not estimate production costs).

Table 6 - Economic viability of feeding dairy cows with diets containing different levels of soybean oil, considering the bonuses paid for milk protein and milk fat content

Item	Level of soybean oil in the diet (% DM)			
	0%	1.5%	3.0%	4.5%
A - Additional cost associated with soybean oil feeding (R$/animal/day)	0.0000	0.4300	0.7900	1.4300
B - Bonus paid for milk protein content (R$)[1]	0.1142	0.1200	0.1168	0.3525
C - Bonus paid for milk fat content (R$)[2]	0.0000	0.0000	0.0000	0.0000
D - Balance (R$) = (B +C) – A (R$)	0.1142	-0.3100	0.67316	-1.0775
E - Is it economically viable?	Yes	No	No	No

[1] Value of the bonus pay per protein/kg of milk × milk yield.
[2] Value of the bonus pay per fat/kg of milk × milk yield according to the criterion utilized by Gimenes & Ponchio (2006).

Table 7 - Balances and economic viability of feeding dairy cows with diets containing different levels of soybean oil considering different scenarios

Item	Level of soybean oil in the diet (% of DM)			
	0	1.5	3.0	4.5
Real scenario: milk price and average inputs				
Bonuses	0.4032	0.3579	0.4355	0.5807
Additional cost associated with soybean oil feeding	0.0000	0.4300	0.7900	1.4300
Balance (R$/cow/day)[1]	0.4032	-0.0721	-0.3545	-0.8493
Is it economically viable?	Yes	No	No	No
Optimistic scenario				
Average milk price[2] and low input prices				
Bonuses	0.4032	0.3579	0.4355	0.5807
Additional cost associated with soybean oil feeding	0.0000	0.3600	0.6800	1.2200
Balance (R$/cow/day)[1]	0.4032	-0.0021	-0.2445	-0.6393
Is it economically viable?	Yes	No	No	No
High milk price[2] and low input prices				
Bonuses	0.4087	0.3627	0.4413	0.5885
Additional cost associated with soybean oil feeding	0.0000	0.3600	0.6800	1.2200
Balance (R$/cow/day)[1]	0.4087	0.0027	-0.2387	-0.6315
Is it economically viable?	Yes	Yes	No	No
High milk price[3] and average inputs				
Bonuses	0.4087	0.3627	0.4413	0.5885
Additional cost associated with soybean oil feeding	0.0000	0.4300	0.7900	1.4300
Balance (R$/cow/day)[1]	0.4087	-0.0673	-0.3487	-0.8415
Is it economically viable?	Yes	No	No	No
Pessimistic scenario				
Average milk price[2] and high input prices				
Bonuses	0.4032	0.3579	0.4355	0.5807
Additional cost associated with soybean oil feeding	0.0000	0.4900	0.8700	1.5900
Balance (R$/cow/day)[1]	0.4032	-0.1321	-0.4345	-1.0093
I it economically viable?	Yes	No	No	No
Low milk price[4] and high inputs				
Bonuses	0.3926	0.3484	0.4239	0.5653
Additional cost associated with soybean oil feeding	0.0000	0.4900	0.8700	1.5900
Balance (R$/cow/day)[1]	0.3926	-0.1416	-0.4461	-1.0247
Is it economically viable?	Yes	No	No	No
Low milk price[4] and average input prices				
Bonuses	0.3926	0.3484	0.4239	0.5653
Additional cost associated with soybean oil feeding	0.0000	0.4300	0.7900	1.4300
Balance (R$/cow/day)*	0.3926	-0.0816	-0.3661	-0.8647
Is it economically viable?	Yes	No	No	No
Alternative scenario				
Low milk and input prices[4]				
Bonuses	0.3926	0.3484	0.4239	0.5653
Additional cost associated with soybean oil feeding	0.0000	0.3600	0.6800	1.2200
Balance (R$/cow/day)[1]	0.3926	-0.0116	-0.2561	-0.6547
Is it economically viable?	Yes	No	No	No
High milk and input prices				
Bonuses	0.4087	0.3627	0.4413	0.5885
Additional cost associated with soybean oil feeding	0.0000	0.4900	0.8700	1.5900
Balance (R$/cow/day)[1]	0.4087	-0.1273	-0.4287	-1.0015
Is it economically viable?	Yes	No	No	No

[1] Balance = ((Bonus paid for milk fat content + bonus paid for milk protein content) – (additional cost associated with soybean oil feeding in R$/animal/day)); Milk prices:
[2] R$ 0.75/kg of milk.
[3] R$ 0.76/kg of milk;
[4] R$ 0.74/kg of milk.

Conclusions

The addition of soybean oil to diets of dairy cows was economically non-viable, since the bonuses paid for milk fat and protein contents were insufficient to offset the additional costs associated with soybean oil feeding. All the dietary soybean oil levels would result in bonuses for milk protein content according to the simulation based on two different criteria adopted by dairy companies in Brazil. Only the control diet (without soybean oil) would result in bonuses for milk fat content considering one of the two criteria. When the MOP scenarios were simulated, the best economic viability was observed for the control diet. The decision for the level of soybean oil to be added to the diet of dairy cows should consider not only the productive efficiency of the animals, but also the associated changes in milk composition and the final value paid for the product.

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