Acta Scientiarum
http://www.uem.br/acta
ISSN printed: 1806-2636
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v38i3.31150

Economic viability of including palm kernel cake in diets for feedlot lactating cows

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ABSTRACT. This study aimed to evaluate the inclusion of palm kernel cake in the diet for lactating crossbred cows in feedlot system, and its implications on economic viability. We used 12 crossbred Holstein x Zebu cows assigned to three 4 x 4 Latin Squares, in the following treatments: control (without inclusion of palm kernel cake in the diet); inclusion of 50, 100 or 150 g palm kernel cake (PKC) per kg in the total dry matter (TDM). Earnings per animal showed a reduction in values, this decrease in profitability is related to the increase in feed costs, specifically, and the costs with concentrate, which increased as the palm kernel cake was included in the treatments, 0, 50, 100 and 150 g kg^{-1} TDM. The effect observed for profitability affected the internal rate of return, which decreased with the inclusion of palm kernel cake levels in the diet. However, it was positive in all treatments, demonstrating the feasibility of investment in palm kernel cake. Data on the economic viability evidenced that treatment with 100 g palm kernel cake per kg TDM is the most financially viable under the conditions of this study.

Keywords: economic analysis, costs, profits, gross income.

Viabilidade econômica da inclusão de torta de dendê em dietas para vacas lactantes em confinamento

RESUMO. Este trabalho foi realizado para avaliar a inclusão de torta de dendê na dieta de vacas mestiças lactantes em confinamento e suas implicações sobre a viabilidade econômica. Foram utilizadas 12 vacas mestiças Holandês x Zebu, distribuídas em três Quadrados Latinos 4 x 4, nos seguintes tratamentos: controle (sem inclusão de torta de dendê na dieta); inclusão de 50 g torta de dendê (TD) por kg na matéria seca total (MST); inclusão de 100 g TD kg^{-1} na MST; inclusão de 150 g TD kg^{-1} na MST. O lucro por animal apresentou uma redução de valores. Esta diminuição na lucratividade está relacionada com o aumento nos custos de alimentação, especificamente, e os custos com concentrado, que aumentaram à medida que a torta de dendê foi incluída nos tratamentos, 0, 50, 100 e 150 g TD kg^{-1} de MST. O efeito observado para a lucratividade alterou a taxa interna de retorno, que diminuiu com a inclusão dos níveis de TD na dieta. No entanto, foi positiva em todos os tratamentos, demonstrando que é viável o investimento na TD. Os dados da viabilidade econômica demonstram que o tratamento com 100 g kg^{-1} de TD na MST é o mais viável financeiramente, nas condições de realização desta pesquisa.

Palavras chave: análise econômica, custos, lucro, renda bruta.

Introduction

Cake derived from biodiesel production have great potential for use in ruminant feed, given the considerable concentrations of protein and ether extract, turning them into protein and/or energy foods, able to meet the nutritional requirements of these fractions by animals (Oliveira et al., 2012).

According to Carvalho et al. (2006), the palm kernel cake obtained after oil extraction, can be used in ruminant feed; however, its use in animal feed should be given attention by the high concentration of NDF and possible low palatability. However, the improper disposal of cake not used in animal feeding can compromise the water table due to the concentration of nitrogen in this waste.

The inclusion of co-products in ruminant feed is advantageous for farmers, because besides reducing the cost of food, it usually keeps productivity and product quality, provided that diets are balanced to meet the nutritional requirements of animals. In some cases there may be a drop in productivity, but this will be compensated for lower production costs without profitability loss. Thus, these co-products are best suited for those who can buy them at low prices, close to their properties, otherwise there will be a reduction in profit margins (Oliveira et al., 2012).

Any activity of the agricultural sector to remain competitive must be evaluated continually in the economic aspect. Production costs, the obtained revenue and return on invested capital are important factors for the success of any production system. This analysis allows the detection of the item at any given time, which can derail the activity, such as price fluctuations in the market (Peres et al., 2004; Silva et al., 2010).

The use of co-products in animal feed, especially in ruminant nutrition, will result in increased demand with consequent reduction in price differential advantage of traditional ingredients. When including these co-products, the farmer should be aware of their availability, nutritional quality and cost compared to traditional foods (Oliveira, Leão, Abreu, Teixeira, & Silva, 2013).

Given the above, this study evaluate the effect of including palm kernel cake in the diet for lactating crossbred cows in feedlot system, and its implications on economic viability.

Material and methods

The experiment was conducted at Paulistinha Farm, municipality of Macarani, state of Bahia, according to the ethical standards and approved by the Research Ethics Committee of the State University of Southwest Bahia, protocol 130/2016. Twelve Holstein × Zebu (½ to ¾ Holstein) cows were used in the experiment. Cows were at the third or fourth lactation, with previous production between 2,500 and 3,500 kg, adjusted for 300 days, at an average 64±13.32 days in milk at the beginning of the experimental period. The twelve dairy cows were distributed into three 4 × 4 Latin squares, with the following treatments: control (no inclusion of PCK in the diet); inclusion of 50 g PCK kg^{-1} in the total dry matter (TDM); 100 g PCK kg^{-1} in the TDM; and 150 g PCK kg^{-1} in the TDM.

The forage used was sugarcane (*Saccharum officinarum*), variety RB 72454, treated with 1% mixture of urea and ammonium sulfate (9:1), in the experimental phase. Following the recommendations of Santos (2014) for a period of 7 days before the onset of the experiment, the cows received the forage with the mixture containing 0.5% urea, in order to adapt to this constituent added, preventing thereby a possible poisoning.

The level of concentrate supplementation was defined by balancing the diets to contain nutrients sufficient for maintenance, body weight gain of 0.15 kg day^{-1} and producing 15 kg milk per day, according to National Research Council (NRC, 2001),based on data of chemical composition of sugarcane, corn, soybean meal and palm kernel cake, held before the trial. The proportions of ingredients in the concentrate are shown in Table 1, on a dry matter basis.

Table 1. Proportions of the ingredients on a dry matter basis.

Ingredients	Level of inclusion of palm kernel cake (g kg^{-1})			
	0.0	50.0	100.0	150.0
Sugar cane	684.0	649.2	610.1	575.0
Corn meal	227.4	221.6	219.4	213.3
Soybeanmeal	70.8	65.9	62.0	56.9
Palm kernel cake	0.0	43.0	91.6	138.5
Mineral salt[1]	10.1	10.2	10.1	10.2
Dicalciumphosphate	5.0	4.2	3.1	2.1
Limestone	2.5	3.2	3.5	3.8

[1]Composition: Calcium 200 g; Cobalt 200, and Copper 1,650 mg; Sulfur 12 g; Iron 560 mg; Fluorine (max) 1,000, and Phosphorus 100 g; Iodine 195 mg; Magnesium 15 g; Manganese 1,960; Nickel 40, and Selenium 32 mg; Sodium 68 g; Zinc 6,285 mg.

The experiment consisted of four experimental periods of 19 days each, the first 14 days were considered for adaptation. Forage and supplements were sampled in each period for evaluation of chemical composition of the diets (Table 2).

Table 2. Chemical composition of sugarcane and diets.

Components	Sugar cane+ urea	Level of inclusion of palm kernel cake (g kg^{-1}DM)			
		0.0	50.0	100.0	150.0
Brix[1]	18.51	-	-	-	-
Dry matter	297.1	377.2	388.6	402.9	417.4
Crude protein	107.1	123.1	123.5	123.6	127.1
Ether extract	13.8	16.2	17.9	20.0	22.5
Neutral detergent fiber$_{ap}$[2]	585.4	446.5	432.7	438.8	447.9
Acid detergente fiber	485.8	382.9	384.6	394.2	377.0
Non-fiber carbohydrates	343.7	445.9	455.1	444.5	426.5
Total carbohydrates	867.5	851.2	848.9	847.0	840.5
Lignin	98.5	49.2	70.0	82.9	99.9

[1]Concentration of soluble sugars in sugarcane; [2]Neutral detergent fiber corrected for ash and protein.

Palm kernel cake was analyzed for chemical composition (Table 3). This material was purchased from the company Palm Oils SA Agro Industrial, located in the municipality of Taperoá, state of Bahia.

Table 3. Chemical composition of the palm kernel cake.

Component (g kg^{-1}DM)	Palm kernelcake
Dry matter(g kg^{-1}food)	922,5
Crude protein	143,4
Ether extract	105,6
Neutral detergent fibera$_{ap}$[1]	656,3
Acid detergent fiber	464,2
Lignin	183,1
Mineral matter	31,3

[1]Neutral detergent fiber corrected for ash and protein.

Animals were housed in individual pens of 16 m^2, roofed, provided with trough and drinker, supplied by gravity, 200 L capacity, common to two bays. Feed was given in the form of complete mixture, twice a day, at 07:00 and 15h00min, ad libitum, to allow 10% leftovers.

Milk yield was evaluated from the 15th to the 19th day of each experimental period, weighed two times per day. The 3.5% fat corrected milk yield (CMY), was estimated according to Sklan, Ashkenazi, Braun, Devorin,and Tabori (1992), by the following equation: CMY = (0.432 + 0.1625 × % milk fat) × milk yield in kg day.

From the 15th to the 19th day of each experimental period, the food supplied and the leftovers were weighed to determine the intake and sampled for chemical analysis. Samples of leftovers and food supplied, sugarcane and concentrate were frozen at -20°C; subsequently thawed, pre-dried and compound per animal and per period on a dry weight basis. At the end of the trial period, samples were ground in a mill with 1 mm sieve, placed in jars with lids and stored for further analysis.

Analyses of dry matter (DM), crude protein (CP), ether extract (EE), lignin (Lig) and mineral matter (MM) of the diets were made following the AOAC standard procedures (Association of Official Analytical Chemists [AOAC], 2005) and acid detergent fiber (FDA), according to Van Soest, Robertson, and Lewis (1991). Neutral detergent fiber free of ash and protein (NDFap) was calculated according to Mertens (2002) and Licitra, Hernandez, and Van Soest (1996). Non-fiber carbohydrates (NFC) of the samples containing no urea were calculated by the Equation 1 proposed by Detmann and Valadares Filho (2010):

$$NFC = 100 - (\%CP + \%EE + \%ash + \%NDFap) \quad (1)$$

where:
%CP = crude protein content,
%EE = ether extract content,
%ash = ash content and
%NDFap = neutral detergent fiber corrected for ash and protein.

NFC of the samples containing urea was calculated with the equation, using the following Equation 2:

$$NFC = 100 - (\%CP - \%CPU + \%N) + \%MM + \%EE + \%\ NDFap \quad (2)$$

where:
CPU = content of crude protein derived from urea and
%U = urea content.

Animals were weighed twice at the beginning and three times at the end of each period to verify the variation in body weight in each diet.

Feces were collected directly from the rectal ampulla, twice daily, at 08.00 hour of the 16th day and at 15.00 hour of the 17th day of each period (Vagnoni, Broderick, Clayton,& Hatfield, 1997). Feces were placed in plastic bags and stored at -20°C. At the end of the collection period, fecal samples were thawed, dried in a forced ventilation oven at 55°C for 72-96 hours and subsequently ground in a mill with a 1 mm sieve and stored for further analysis.

Information for the assessment of economic viability; breakdown of costs as well as the data used (prices, lifespan etc.) were collected from the farmers, rural extension technicians and businesses in the region in November 2013. Land use was calculated by the average consumption and production of sugarcane in the property used. In the price of dry matter of sugarcane, we embedded expenditure on deployment, maintenance and recovery of the sugarcane plantation. For manure production, it was used fecal output, calculated by the indigestible fraction of DM in the total feed, for each treatment.

To evaluate the production cost, we considered the methods of operating costs, used by the Institute of Applied Economic Research – Ipea (Matsunaga, Bemelmans, & Toledo, 1976). Depreciation of improvements, machinery, equipment and service animals were estimated by linear method of fixed quotas, with a final value of zero. For the remuneration of the capital, we used real interest rate of 6% per year.

For economic analysis, we used two economic indicators: NPV (net present value) and IRR (internal rate of return). The expression for NPV calculation is as follows Equation 3:

$$NPV = \sum_{t=0}^{n} NF/(1 + r)^t \quad (3)$$

where:
NPV = net present value;
NF = net flow value (difference between inputs and outputs);
n = number of flows;
r = discount rate;
t = period of analysis (i = 1, 2, 3...).

In calculating the NPV, we applied three discount rates on the monthly net flow of each production system. The adopted rates were 6, 10 and 12% per annum.

For IRR, according to the acceptance criteria, the greater the results obtained in the project, the greater the attractiveness to its implementation. Thus, the IRR is the value of r which equals to zero the following Equation 4:

$$NPV = NF_0 + \frac{VF_1}{(1+r)^1} + \frac{NF_2}{(1+r)^2} + \frac{NF_3}{(1+r)^3} + \frac{...}{...} + \frac{NF_n}{(1+r)^n} \quad (4)$$

where:
NF = Net cash flows (0, 1, 2, 3,...,n),and;
r = discount rate.

To calculate the IRR and NPV, there was a simulation of a year to study economic characteristics, being thus computed the depreciation of improvements and machinery in this period.

Table 4 lists the values of milk and manure sales used in the experiment.

Table 4. Average selling price of products in the experimental period.

Product	Unit	Unit value (R$)
Milk	Liters (L)	0.95
Manure	Tons	10.00

Tables 5, 6, 7 and 8 show, in detail, data on prices of inputs and services, prices of ingredients in the concentrate, the amount of inputs and services per cow and per treatment and the value of improvements, machinery, equipment, service animal and land, used in the experiment.

The data, except for the economic viability, were evaluated by analysis of variance and regression, using the System for Statistical and Genetic Analysis. The statistical models were chosen according to the significance of the regression coefficients using the F-test at 5% probability and coefficient of determination (R^2). The indices of economic viability were compared by descriptive analysis using the application MS Excel®.

Table 5. Prices of inputs and services used in the experiment.

Discrimination	Unit	Unit value (R$)
Sugarcane 1% USA^{-1}	kg DM	0.20
Vermifuge	mL	0.06
Acaricide	mL	0.09
FMD vaccine	Dose	1.25
Drugs*	mL	0.15
Hand labor	d hour^{-1}	35.00

*Average prices of some drugs that were eventually used.

Table 6. Prices of concentrate used in the experiment.

Concentrate (Level of Palm kernel cake %)			
0	5	10	15
0.86	0.80	0.75	0.72

Table 7. Prices of ingredients of concentrate used in the experiment.

Discrimination	Unit price (R$ kg^{-1})
Corn	0.58
Soybean	1.46
Mineralsalt	2.08
Dicalciumphosphate	2.80
Limestone	0.24
Palm kernelcake	0.50

Table 8. Lifespanand value of improvements, machinery, equipments, animals and land, amount used in the experiment and total value.

Discrimination	Vida útil (days)	Unit value (R$)	Amountused (Unit)	Total value (R$)
Barnyard balance– 1500 kg	5475	2640.00	1	2640.00
Forage grinder	5475	3500.00	1	3500.00
Tippedshovel	730	25.00	1	25.00
Wheelbarrow	730	110.00	1	110.00
Four teethfork	730	25.00	1	25.00
Smallvalueutilities	730	35.30	1	35.30
Feedlotshed	5475	8000.00	1	8000.00
Cows	-	3000.00	16	48000.00
Baresoil	-	5000.00	4	20000.00
Fixedamountinvested	-			82335.00

Results and discussion

There was no effect of the use of palm kernel cake ($p > 0.05$) on dry matter intake, 15.2 kg day^{-1} (Table 9), indicating that, despite the increased inclusion of palm kernel cake up to 100 g kg^{-1} TDM, which has high content of fiber, lignin and EE, it did not affect the intake.

In this work, there was no effect of palm kernel cake levels ($p > 0.05$) on dry matter intake in relation to body weight (BW), with an average of 3.20%. According to Mertens (1994), the basis for expressing the intake in relation to metabolic weight or percentage of body weight depends on the intake limitation, if it was due to energy or filling, respectively.

There was no effect of including palm kernel cake levels in the diet on milk production ($p > 0.05$) (Table 9). The milk production corrected to 3.5% fat showed a linear increase ($p < 0.05$), according to an increase of 0.474 kg for every 1% palm kernel cake added to the diet. The determination of this parameter allows for better characterization of production efficiency, when evaluating co-products in the diet for dairy cows, because of variations in body size of cows used in different production systems existing in Brazil.

Table 9. Dry matter intake, milk production, milk production corrected for 3.5 % fat.

	Level of inclusion of palm kernel cake (g kg^{-1} DM)				Eq.[1]	CV%[2]	P[3]
	0	50	100	150			
Dry matter intake (kg day^{-1})	14.71	14.89	15.74	15.52	15.21	7.93	0.133
Drymatterintake (% BW)	3.08	3.12	3.24	3.34	3.20	11.93	0.324
Milkproduction (kg day^{-1})	11.96	12.09	12.78	12.53	12.34	6.64	0.069
Milk production G[4](kg day^{-1})	12.78	13.47	14.24	14.11	[5]	6.64	0.001

[1]Regression equations; [2]Coefficient of variation in percent; [3]Error probability; [4]Milk production corrected for 3.5% fat; [5]$\hat{Y} = 12.463 + 0.474x$, $R^2 = 0.84$.

Moreover, Cunha et al. (2012) assessed the inclusion of palm kernel cake at 0; 12; 23 and 34% in the total diet for dairy cows and observed that milk production decreased linearly with the addition of palm kernel cake. The authors found that despite the reduction in production costs with the inclusion of palm kernel cake, there was a concomitant animal weight loss and reduced milk production. In the present study, it was observed that the inclusion of up to the level of 15% palm kernel cake in the diet did not affect milk production and milk production corrected increased with inclusion of palm kernel cake.

Values of gross income per animal (Table 10) were similar between treatments, since milk production was not changed by the inclusion of palm kernel cake, using average values of milk production for obtaining the same.

The value of the effective operational cost, which indicates the amount of resource directed to cover actual expenses, increased with the increased level of palm kernel cake in the diet, once it was necessary to increase the amount of palm kernel cake in the concentrate to provide an isoproteic and isoenergetic diet. Hence, it was obtained a higher concentrate cost, although reducing the amount of sugarcane with increasing levels of palm kernel cake. This is the forage fraction of the diet, which has lower cost. This highlights the importance of the participation of the feed cost in overall total costs, reaching 66.78% of the total cost to the lowest level of palm kernel cake.

Cunha et al. (2012) conducted a bioeconomic evaluation on the use of palm kernel cake in the diet for dairy cows using levels of 0.0; 11.34; 22.78 and 34.17%, and reported that, by evaluating the feed costs and gross margin, diets with 0.0 and 11.34% palm kernel cake are uneconomical, because the gross margin was negative. In this study, the addition of 50 and 100 g PKC kg^{-1} TDM resulted in similar feed costs and similar gross margin, and the use of 150 g PKC kg^{-1} TDM resulted in a lower gross margin between treatments.

Values of total operating expense and total cost (Table 11), which includes depreciation and return on capital, showed the same behavior of the effective operational cost, as the same infrastructure and animals were used in all treatments, noting an increase with inclusion of palm kernel cake in the diet.

Table 10. Gross income and effective operational cost.

Economic indicator	U[1]	Unit price(R$)	Level of inclusion of palm kernel cake (g kg^{-1} DM)							
			0		50		100		150	
			Amount	Value	Amount	Value	Amount	Value	Amount	Value
1-Gross income (GI)										
Milksale	kg	0.95	12.34	11.72	12.34	11.72	12.34	11.72	12.34	11.72
Manuresale	kg	0.01	55.33	0.53	49.05	0.49	54.17	0.54	50.84	0.51
Total				12.26		12.21		12.26		12.23
2-Cost										
2.1-Effectiveoperationalcost(EOC)										
Hand labor	$dhour^{-1}$	35	0.06	2.1	0.06	2.1	0.06	2.1	0.06	2.1
Concentrate	kg DM^{-1}		4.81	4.14	5.35	4.28	5.93	4.45	6.46	4.65
Sugargane	kg DM^{-1}	0.2	10.41	2.08	9.88	1.98	9.28	1.86	8.75	1.75
Electric power	kw $hour^{-1}$	0.05	0.27	0.01	0.27	0.01	0.27	0.01	0.27	0.01
Drugs	R$			0.05		0.05		0.05		0.05
Improvements repair	R$			0.1		0.1		0.1		0.1
Machinery Andequipment repair	R$			0.05		0.05		0.05		0.05
Subtotal				8.44		8.48		8.52		8.62

[1]Units: kg = kilograms; $dhour^{-1}$ = daily; kg DM^{-1} = kilograms per kilogram of dry matter; kw $hour^{-1}$ = kilowatt hours; R$ = real; R$ kg^{-1} = real per kilogram; % = percentage.

Table 11. Total operating expense, total cost and profit per cow per day.

Economic indicator		Level of palm kernel cake (g kg^{-1} DM)			
		0	50	100	150
2.2- Total operating expense					
2.2.1- Effective operational cost	R$	8.44	8.48	8.52	8.62
2.2.2-Depreciation of improvement	R$	0.09	0.09	0.09	0.09
2.2.3-Depreciation of machinery and equipment	R$	0.09	0.09	0.09	0.09
Subtotal		8.61	8.65	8.7	8.79
2.3-Total cost (TC)					
2.3.1- Total operating expense	R$	8.61	8.65	8.7	8.79
2.3.2-Intereston Capital	R$	0.71	0.71	0.71	0.71
Cost per animal	R$	9.33	9.37	9.42	9.51
Cost per kilogram of milk produced	R$ kg^{-1}	0.76	0.76	0.76	0.77
Profit per animal	R$	2.93	2.85	2.85	2.71
Profit per kilogram of milk produced	R$ kg^{-1}	0.24	0.23	0.23	0.22
EOC TC^{-1}	%	90.43	90.46	90.51	90.61
Expenditure on food	R$	6.21	6.26	6.3	6.4
Expenditure on food EOC^{-1}	%	66.64	66.78	66.94	67.28
Expenditure on concentrate GI^{-1}	%	33.75	35.04	36.26	38.03
EOC GI^{-1}	%	68.84	69.39	69.49	70.48
Gross margin	R$	3.82	3.74	3.74	3.61
Net margin	R$	3.64	3.56	3.56	3.43
Profit	R$	2.93	2.85	2.85	2.72

The total cost per animal increased with the inclusion of growing levels of palm kernel cake in the diet. The cost per liter of milk produced, which includes the return on capital (opportunity cost), was similar between treatments, with a small increase for the treatment with 150 g PKC kg^{-1} TDM.

According to Gomes (2000), expenses with concentrate feed for milk production systems, working with mixed breed cattle in semi-feedlot system, should not exceed 30% relative to the value of production. In this study, the values found were 33.75; 35.04; 36.26 and 38.03%, respectively; and spending on diets exceeded the amount recommended by the author.

Profit per animal showed a reduction in values, which is related to the increase in feed costs, specifically, and the costs of concentrate, which increased as the palm kernel cake was included to the diet (4.14; 4.28; 4.45; 4.65) in treatments 0, 50, 100 and 150 PKC g kg^{-1} TDM, respectively, demonstrating that its use was not efficient in financial aspect.

The effect found for profitability influenced the internal rate of return (IRR), which decreased with the inclusion of increasing levels of palm kernel cake in the diet, since it has reduced the forage: concentrate ratio. Treatment with 150 g PKC kg^{-1} TDM achieved a lower internal rate of return, due to the increase of the concentrate fraction, which is the most costly fraction of the feed. Nevertheless, it was positive in all treatments, showing that investment in palm kernel cake is feasible (Table 12).

Table 12. Monthly internal rate of return and net present value for rates of return of 6, 10 and 12%, respectively, for a year.

Economicindicator	Level of palm kernel cake (g kg^{-1} DM)			
	0	50	100	150
Internal rate of return	1.98%	1.94%	1.95%	1.87%
Net presente value 6%	15074.74	14629.69	14650.22	13923.25
Net presente value10%	11432.95	10998.59	11018.63	10309.14
Net presente value12%	9626.75	9197.77	9217.56	8516.85

The calculation of the net present value (NPV), which is cash value that capital is paid, discounted a rate, showed that this investment is viable for all discount rates used in all diets, and it was more interesting to invest in dairy activity when compared to the opportunity cost of all tested interest rates. However, up to 100 g PKC kg^{-1} TDM inclusion, there was a better economic return.

Conclusion

Data on economic viability show that treatment with 100 g palm kernel cake per kg in the diet is the most financially viable under the conditions of this study.

There was no reduction in productivity with the inclusion of palm kernel cake in the levels tested, but a greater rate of return was found with up to 100 g kg^{-1} palm kernel cake. Therefore, this co-product is indicated for farmers who can buy it at low prices, close to their properties, otherwise profit margins may be reduced.

Acknowledgements

To the Brazilian National Council for Scientific and Technological Development (CNPq) for granting the scholarship.

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Received on February 28, 2016.
Accepted on March30, 2016.