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# Productive performance and milk protein fraction composition of dairy cows supplemented with sodium monensin

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**ABSTRACT** - The objective of this work was to evaluate the levels of sodium monensin on lactating cows and their effects on productive performance and milk protein fraction composition. It was used 12 Holstein cows, distributed in four balanced 3 × 3 Latin squares, and fed three diets: one control without monensin, and two diets with monensin at the levels of 24 or 48 mg/kg DM added to the concentrate. Milk production was daily measured throughout the entire experimental period. The samples used for analysis of milk composition were collected on two alternated days from the two daily milking. Non-protein nitrogen, total nitrogen and non-casein nitrogen contents were directly evaluated in the milk, and casein, whey protein and true protein contents were indirectly determined. The use of monensin in the rations reduced dry matter and nutrient intake, especially when diet with 48 mg/kg of dry matter was given. The ration with 24 mg/kg of DM increased milk production, with or without correction, and also fat and lactose yield, and it improved productive efficiency. The levels of monensin in the ratios did not influence contents of milk crude protein, non-protein nitrogen, non-casein nitrogen, true protein, casein, casein/true protein ratio, whey protein, and of all those fractions expressed as percentage of crude protein. The utilization of monensin in the ratio at the dose of 24 mg/kg of DM influences positively the productive performance of lactating cows, and it does not influence the composition of milk protein fractions.

Key Words: casein, dairy cows, ionophores, milk yield and composition, productive efficiency

# Desempenho produtivo e composição da fração protéica do leite em vacas sob suplementação com monensina sódica

**RESUMO** - Objetivou-se avaliar níveis de monensina sódica para vacas em lactação e seus efeitos no desempenho produtivo e na composição da fração protéica do leite. Foram utilizadas 12 vacas da raça Holandesa, distribuídas em quatro quadrados latinos 3 × 3 balanceados e alimentadas com três rações: uma controle sem monensina, e duas com monensima nos níveis de 24 mg/kg de matéria seca ou 48 mg/kg MS adicionada ao concentrado. A produção de leite foi mensurada diariamente durante todo o período experimental. As amostras utilizadas para análise da composição do leite foram coletadas em dois dias alternados e provenientes das duas ordenhas diárias. Foram analisados no leite os teores de nitrogênio não-protéico, nitrogênio total e nitrogênio não-caseinoso e indiretamente os teores de caseína, proteína do soro e proteína verdadeira. A utilização de monensina nas rações ocasionou redução do consumo de MS e de nutrientes, especialmente quando fornecida a ração com 48 mg/kg de MS. A ração com 24 mg/kg de MS promoveu aumento da produção de leite, sem e com correção, e da produção de gordura e lactose e aumento da eficiência produtiva. Os níveis de monensina nas rações não influenciaram os teores de proteína bruta, nitrogênio não-protéico, nitrogênio não-caseinoso, proteína verdadeira, caseína, relação caseína/proteína verdadeira, proteína do soro do leite e de todas essas frações expressas em porcentagem da proteína bruta. A utilização de monensina na ração na dose de 24 mg/kg de MS influencia positivamente o desempenho produtivo de vacas em lactação e não afeta a composição das frações protéicas do leite.

Palavras-chave: caseína, eficiência produtiva, ionóforos, produção e composição do leite, vacas leiteiras

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## Introduction

Sodium monensin is an ionophore approved for usage on lactating dairy cows in several countries, including Australia, Argentina, Canada, Brazil, New Zealand, South Africa, and recently, the United States. Monensin is a carboxylic poyeter, ionophore, produced from the fungi *Streptomyces cinnamonensis* (Haney & Hoehn, 1967), which alters the flux of monovalent ions in the membrane of gram-negative bacteria by interrupting its normal function and causing its lisys (Duffield & Bagg, 2000).

The mode of action of ionophores results in an alteration of ruminal bacterial populations, with several impacts on the metabolism of ruminants, including improvements on energy and protein metabolisms. The increase of gram-negative bacteria participation in the rumen alters the final products of fermentation by increasing propionate proportion and reducing acetate and butyrate proportions (McGuffey et al., 2001).

Researches that involve ionophores for lactating cows have produced divergent results, indicating an interaction among diet and involved physiological effects (Ipharraguerre & Clark, 2003). Reviews by Mc Guffey et al. (2001) and Ipharraguerre & Clark (2003) suggested that the reduction on intake, a characteristic verified in beef cattle, seems to occur more often when cows are in the mid and late lactation. Similarly, according to these authors, based on the potential of monensin to increase the supply of gluconeogenic precursors such as propionate, its administration for lactating cows can increase hepatic glucose synthesis, therefore improving the energy balance, with a consequent increase on milk yield.

The interest in milk protein has increased in the last decades because of its nutritional and economic aspects. (Botaro et al. 2009) High concentrations of milk true protein are desirable for the dairy industry demand (Emmons et al., 2003). Milk nitrogen fractions are composed by casein, whey protein, and non-protein nitrogen, the former two are the milk true protein fraction. The non-protein nitrogen fraction corresponds from 5 to 6% of total nitrogen of milk, and almost 50% of this fraction is constituted by urea (DePeters & Cant, 1992).

In this context, the objective of this work was to evaluate the productive performance and milk protein fraction composition on lactating dairy cows supplemented with sodium monensin.

## Material and Methods

The experiment was conducted on the Confinamento experimental da Universidade de São Paulo at the Pirassununga campus, from October to December, 2007. It was used 12 Holstein cows, which were allocated in individual stalls with an average production of 25 kg of milk/day in the beginning of the experiment, and means from 157 to 214 days of lactation in the beginning and at the end of the experiment, respectively.

The cows were distributed in four balanced 3 × 3 Latin squares. The experiment was composed by three 19-day periods (14 days of adaptation to the diets and 5 days of sample collection). The animals were randomly distributed and fed control diet, without monensin, or one of the two experimental diets, constituted by basal diet added with sodium monensin (Bobiovet 10 Premix®, Indukern do Brasil Química Ltda.) at the proportions of 24 mg/kg or 48 mg/kg of dry matter, added as a premix to the concentrate. The respective diets, water, and mineral salt were supplied *ad libitum* during the whole experimental period. The roughage used during the experiment was corn silage.

All diets were formulated to be isonitrogenous and isoenergetic, in a way to attend the nutritional requirements of lactating cows at approximately 580 kg of live weight, 20 weeks of lactation, daily producing 25 kg of milk with 3.5% of fat, according to recommendations of the NRC (2001).

The quantities of supplied roughage and concentrate as well as the orts of each experimental diet were daily weighed to estimate individual intake. The animals were fed according to the dry matter intake of the previous day, to keep 5-10% of orts as not to limit the intake. After preparing the mixture in the feedbunk, the samples of the supplied ingredients were collected and stored at -20ºC. Chemical analyses were later realized in the stored samples. Sample collections were carried out in the end of each experimental period, after the adaptation period to the diets.

In the supplied ingredients and orts samples, it was determined the contents of dry matter, organic matter, mineral matter, ether extract, neutral detergent insoluble nitrogen, acid detergent insoluble nitrogen and lignin according to the methodologies described by Silva & Queiroz (2002). The content of crude protein (CP) was obtained by multiplying the total nitrogen ratio by 6.25 and the neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined according to method described by Van Soest et al. (1991), using $\alpha$–amylase without addition of sodium sulfite to determine neutral detergent fiber (Tables 1 and 2).

The total carbohydrate contents (TC) were calculated according to Sniffen et al. (1992): TC = 100 – (%CP + %EE + %Ash); non fiber carbohydrates (NFC), according to Hall (2000): NFC = 100 – [(%CP– %CP urea + %urea) + %EE +

%MM + % NDF]; total digestible nutrient (TDN), according to Weiss (1999): TDN (%) = DCP + DNDF + DNFC + (DEE × 2.25), in which: DCP = digestible crude protein; DNDF = digestible fractions of NDF; DNFC = digestible non-fiber carbohydrate; DEE = digestible ether extract; and net energy of lactation ($NE_L$), according to NRC (2001), where $NE_L$ (Mcal/kg) = [0.703 × Metabolizable energy (Mcal/kg)] – 0.19. The nutrients and net energy of lactation intakes were evaluated.

The animals were mechanically milked twice a day, at 6 a.m. and 4 p.m, and the milk yield was daily registered throughout the entire experimental period to follow up the performance of the animals. The 3.5% fat corrected milk yield (FCM) was obtained according to Sklan et al. (1994), in which FCM = (0.432 + 0.1625 * G) * kg, where G = % milk fat content.

Table 1 - Composition of ingredients of concentrate and of experimental diets

| Ingredient (% DM) | Concentrate | Diets |
|---|---|---|
| Corn silage | - | 58.00 |
| Ground corn | 52.14 | 21.90 |
| Soybean meal | 39.10 | 16.42 |
| Urea | 1.74 | 0.73 |
| Ammonium sulfate | 0.12 | 0.05 |
| Sodic bicarbonate | 1.48 | 0.62 |
| Magnesium oxide | 0.05 | 0.02 |
| Mineral mixture[1] | 4.67 | 1.96 |
| Limestone | 0.24 | 0.10 |
| Common salt | 0.48 | 0.20 |

[1] Composition by kg of mineral mixture: Calcium - 180 g; Phosphorus - 90 g; Magnesium - 20 g; S - 20 g; Sodium - 100 g; Zinc – 3,000mg; Copper - 1,000 mg; Manganese - 1,250 mg; Iron – 2,000 mg; Cobalt - 200mg; I - 90mg; Selenium - 36 mg; Fluorine - 900 mg (max.).

Table 2 - Nutritional composition of silage, concentrate, and experimental diets

| Nutrient | Concentrate | Corn silage | Diets |
|---|---|---|---|
| Dry matter (%NM) | 89.42 | 28.96 | 54.36 |
| Organic matter (%DM) | 89.98 | 94.47 | 92.58 |
| Crude portein (%DM) | 27.73 | 8.82 | 16.77 |
| NDIN[1,4] | 13.19 | 19.79 | 17.02 |
| ADIN[1,4] | 4.73 | 13.53 | 9.83 |
| Ether extract (%DM) | 2.90 | 2.91 | 2.91 |
| Total carbohydrates (%DM) | 59.34 | 82.74 | 72.91 |
| Neutral detergent fiber (%DM) | 14.72 | 57.37 | 39.46 |
| NDFAP[2] (%DM) | 9.89 | 53.20 | 35.01 |
| Non fiber carbohydrates (%DM) | 51.13 | 25.37 | 36.19 |
| NFCAP[3] (%DM) | 55.96 | 29.54 | 40.63 |
| Acid detergent fiber (%DM) | 7.94 | 37.46 | 26.08 |
| Lignin (%DM) | 1.07 | 5.44 | 3.61 |
| Mineral matter (%DM) | 10.02 | 5.53 | 7.42 |
| Total digestible nutrients[5] | 82.48 | 62.73 | 71.02 |
| Net energy of lactation5 | 2.11 | 1.47 | 1.74 |

[1] NDIN = neutral detergent insoluble nitrogen; ADIN = acid detergent insoluble nitrogen. [2] $NDF_{AP}$ = NDF corrected for ash and protein. [3] $NFC_{AP}$ = non fiber carbohydrates corrected for ash and protein. NM = natural matter; DM = dry matter. [4] % Total nitrogen. [5] Estimated by NRC equations (2001).

Samples used for analysis of milk composition were obtained on the 13th and 16th day of each experimental period, each sample coming from the two daily milkings. These samples were stored in plastic containers with conserving agent (Bronopol®), kept between 2 and 6ºC, and sent to the Laboratório de Tecnologia de Produtos de Origem Animal in the Departmento de Nutrição e Produção Animal, at Faculdade de MedicinaVeterinária e Zootecnia - USP to obtain the milk composition. Crude protein, fat, lactose and total dry extract contents were evaluated according to the methodology described by the International Dairy Federation (1996).

The body condition score (BCS) and body weight were measured on the seventh day of adaptation and at the end of each experimental period to evaluate weight changes. The weight of the animals corresponded to the mean of two successive weightings conducted before feeding and after milkings during two days. For calculating the variation of the body condition score and of body weight, the weights for the seventh day of adaptation and at the end of the experimental period were considered. Measurements of the body condition score were done according to methodology proposed by Wildman et al. (1982) and developed by Edmonson et al. (1989).

To evaluate milk protein fractions, 50 ml samples were collected, representing the daily milk yield from cows. The samples were identified and stored in a freezer at –20º C. The non-protein nitrogen (NPN), total nitrogen (TN) and milk casein analyses were performed according to methodologies used at the Laboratório de Tecnologia de Produtos de Origem Animal in the Departmento de Nutrição e Produção Animal, at Faculdade de MedicinaVeterinária e Zootecnia, at FMVZ-USP.

The reference method used to determine milk and dairy product protein concentrations is based on total nitrogen measurement by the Kjeldahl method, according to the methodologies described by Association of Official Analytical Chemists (1995), method number 33.2.11; 991.20. The nitrogen was multiplied by the 6.38 factor so as to express the results as total protein or crude protein (Barbano & Clark, 1990).

The fractions of non-casein nitrogen and milk casein were determined using methodology described by Lynch & Barbano (1998). Milk casein was precipitated in pH = 4.6 using acetic acid and sodium acetate solution. After precipitation, casein was separated by filtration, and concentration of filtrated nitrogen (NNC) was determined by Kjeldahl method. Milk casein concentration is determined by the subtraction of total nitrogen by filtrated nitrogen.

Determinantion of milk true protein concentration was performed by the difference between the total protein concentration (crude protein) and non-protein nitrogen concentration, according to methodology described by Association of Official Analytical Chemists (1995), methods numbers 33.2.12; 991.21 and for determining non-protein nitrogen it is necessary a previous preparation of the milk samples, using trichloroacetic acid at 15% for coagulation of all milk proteins. The coagulated protein was removed by filtration, and the filtrated was submitted to the determination of nitrogen concentration by the Kjeldahl method. After determination of non-protein concentration, this was subtracted from the total nitrogen content for determination of the milk true protein concentration.

The data obtained were submitted to analyses of variance and simple polynomial regression with 5% of significance, using the SAS program, version 8.0.

## Results and Discussion

The utilization of sodium monensin in diets decreased dry matter and nutrient intake (P<0.05) (Table 3). In average, dry matter intake was reduced by 2.94% and 12.42%, in M24 and M48 diets, respectively, in comparison to the control diet. Similarly, this reduction was also observed for the nutrient intake. When analyzing the data, greater reduction in the intake was observed for animals submitted to the higher sodium monensin dose, which was 48 mg/kg dry matter in this study.

The mode of action of monensin when decreasing the dry matter intake can be mediated by the increase of propionate concentration, which supplies the demand of glucose by the mammary gland (Oba & Allen, 2003). These authors suggested that increases in the glucose requirement would increase the gluconeogenesis, reducing the propionate oxidation inside the liver, which minimizes the impact of propionate when reducing the dry matter intake.

Ipharraguere and Clark (2003) analyzed studies in which lactating cows were supplemented with sodium monensin in doses above 35 mg/kg of diet dry matter, and they observed that, on average, dry matter intake was reduced by approximately 0.30 kg/day, which represented 1.5% reduction on intake of animals in the monensin group. Duffield et al. (2008) evaluated the effects of sodium monensin on dry matter intake, and concluded that the addition of this supplement decreased intake around 0.30 kg/day when compared to the control diet.

In the study by Eifert et al. (2005), using dose of 33 mg/kg DM of sodium monensin, dry matter intake was reduced by only 1.4%, in comparison to the control diet. The results obtained in this research are similar to the ones verified by the cited authors. However, Martineau et al. (2007), when evaluating cows in mid lactation receiving 24 mg/kg DM of monensin, did not find difference in the intake when compared to the control group. Other authors, such as Ramanzin et al. (1997), and Petersson-Wolfe et al. (2007), using doses of 15 and 22 mg/kg DM of monensin, respectively, obtained similar results.

According to information available in the literature and the results obtained in the present study, it can be observed that alterations on intake when cows are supplemented with monensin depend on the level of supplementation of this ionophore on the diets. Symanowski et al. (2009) used monensin at 0, 8, 16 and 24

Table 3 - Dry matter and nutrient intake in the experimental diets

| Parameters | Experimental diet | | | Means | CV (%) | Probability | |
|---|---|---|---|---|---|---|---|
| | Control, without monensin | Monensin 24 mg/kg of diet | Monensin 48 mg/kg of diet | | | Linear | Deviation |
| Dry matter (kg/day) | 18.03 | 17.50 | 15.79 | 17.10 | 6.10 | <0.001 | 0.127 |
| Dry matter (%LW) | 3.31 | 3.00 | 2.77 | 3.03 | 8.06 | <0.001 | 0.631 |
| Organic matter (kg/day) | 16.71 | 16.22 | 14.66 | 15.86 | 6.11 | <0.001 | 0.132 |
| Crude protein (kg/day) | 2.97 | 2.85 | 2.56 | 2.79 | 7.54 | 0.001 | 0.274 |
| Ether extract (kg/day) | 0.54 | 0.52 | 0.46 | 0.50 | 8.15 | 0.002 | 0.206 |
| Neutral detergent fiber (kg/day) | 7.12 | 6.87 | 6.29 | 6.76 | 6.45 | 0.002 | 0.286 |
| Neutral detergent fiber (%LW) | 1.28 | 1.21 | 1.11 | 1.20 | 5.90 | <0.001 | 0.730 |
| Ash corrected neutral detergent fiber (kg/day) | 6.32 | 6.12 | 5.61 | 6.01 | 6.49 | 0.002 | 0.284 |
| Ash corrected neutral detergent fiber (%LW) | 1.13 | 1.08 | 0.99 | 1.07 | 6.04 | <0.001 | 0.627 |
| Non-fiber carbohydrates (kg/day) | 6.58 | 6.39 | 5.73 | 6.24 | 6.27 | <0.001 | 0.096 |
| Non-fiber carbohydrates corrected (kg/day) | 7.37 | 7.14 | 6.42 | 6.98 | 6.40 | <0.001 | 0.127 |
| Total carbohydrates (kg/day) | 13.20 | 12.81 | 11.62 | 12.55 | 6.12 | <0.001 | 0.158 |
| Total digestible nutrients (kg/day) | 12.96 | 12.36 | 11.28 | 12.20 | 6.17 | <0.001 | 0.381 |
| Net energy of lactation[1] (Mcal/day) | 32.71 | 30.38 | 28.41 | 30.50 | 8.61 | 0.007 | 0.845 |

[1] Calculated according to NRC (2001).

mg/kg DM, and observed reduction of intake in the last two evaluated levels. Similarly, McClary et al. (2005) evaluated different doses of monensin (0, 7, 15, and 22 mg/kg DM) for dairy cows and observed reduction of intake in the last two levels of utilization.

The utilization of 15 to 24 mg/kg DM of sodium monensin on diets of mid-lactation dairy cows seems to be the maximum limit of supplementation which might cause some alteration in the intake. Doses above 35 mg/kg DM of monensin is likely to cause reduction of intake in mid-lactation cows. In the literature, it is not clear the effects of different doses of monensin associated with different basal diets or different roughages. Thus, the responses observed with corn silage based diets, as in the present study, are not completely defined yet.

Increases in milk yield were observed, with and without correction, as well as in fat yield and lactose yield ($P<0.05$) for cows fed intermediate level of sodic monensin in diets (Table 4). The utilization of sodium monensin in the diet at 24 mg/kg DM improved the performance of cows, which started producing 0.66 kg/day or 2.7% more milk on average. Because there was a lower intake and a higher milk production for this diet containing sodic monensin, productive efficiency increased ($P<0.05$).

Cows submitted to the M48 diet had lower milk yield and lower yield of protein components in comparison with the other experimental diets. However, although milk yield and intake were lower, this group showed the best productive efficiency ($P<0.05$). Addition of sodic monensin had no effect ($P>0.05$) on milk fat, protein, and total dry extract contents.

According to Duffield et al. (2008a), addition of monensin in diets of dairy cows can increase milk yield by 0.70 kg/day, and also the efficiency of milk yield by 2.5%, data similar to the ones obtained in the present study. Gallardo et al. (2005) also reported positive effect by adding monensin, which increased milk yield by 4.0% in comparison to the control diet (27.7 vs. 26.6 kg/day, respectively).

Eifert et al. (2005) did not find any effect for milk yield when comparing the experimental diets, although the diet with monensin resulted in a higher value for milk yield (3.0%), in comparison with the control diet (26.5 vs. 26.6 kg/day, respectively). Similarly, Ramanzin et al. (1997); Zahra et al. (2006) and Martineau et al. (2007) did not observe effect of sodium monensin addition on milk yield of lactating cows.

According to the reviews by McGuffey et al. (2001), and Ipharraguerre & Clark (2003), lactating cows that received monensin had responses in milk yield of approximately 1.3 kg/day or 5% higher than non-supplemented cows. The majority of studies with additions to the diet of about 24 mg/kg DM sodic monensin resulted in better productive performance by mid- and late-lactation cows, when compared to the control diet. Similarly, studies that added sodium monensin at around 12 to 20 mg/kg DM, often did not report favorable results on productive performance, the

Table 4 - Daily milk yield, productive performance and milk composition of dairy cows supplemented with sodic monensin

| | Experimental diet | | | Means | CV (%) | Probability | |
|---|---|---|---|---|---|---|---|
| | Control, without monensin | Monensin 24 mg/kg of diet | Monensin 48 mg/kg of diet | | | Linear | Deviation |
| Milk yield (kg/day) | 23.92 | 24.58 | 22.63 | 23.71 | 5.33 | 0.022 | 0.009 |
| Milk yield corrected (kg/day) | 22.53 | 23.41 | 20.71 | 22.22 | 8.53 | 0.028 | 0.015 |
| Fat production (kg/day) | 0.71 | 0.80 | 0.69 | 0.73 | 12.86 | 0.655 | 0.005 |
| Protein production (kg/day) | 0.70 | 0.72 | 0.66 | 0.69 | 18.95 | 0.167 | 0.583 |
| Lactose production (kg/day) | 1.08 | 1.11 | 1.01 | 1.07 | 5.07 | 0.006 | 0.001 |
| Fat (%) | 2.97 | 3.15 | 3.16 | 3.09 | 9.18 | 0.113 | 0.393 |
| Protein (%) | 2.95 | 2.93 | 2.88 | 2.92 | 4.04 | 0.134 | 0.737 |
| Lactose (%) | 4.50 | 4.53 | 4.53 | 4.52 | 1.40 | 0.247 | 0.438 |
| Total dry extract (%) | 11.78 | 11.67 | 11.54 | 11.67 | 2.48 | 0.040 | 0.936 |
| Non-fat extract (%) | 8.50 | 8.44 | 8.38 | 8.45 | 2.15 | 0.115 | 0.934 |
| Body weight (kg) | 559.50 | 579.34 | 565.50 | 568.10 | 3.93 | 0.519 | 0.065 |
| Change of body weight (kg) | 36.67 | 28.58 | 24.17 | 29.80 | - | 0.330 | 0.867 |
| Body condition score (BCS) | 3.00 | 3.01 | 2.97 | 2.99 | 1.93 | 0.194 | 0.206 |
| Change of BCS | 0.06 | 0.06 | 0.62 | 0.07 | - | 0.738 | 0.846 |
| Productive efficiency[1] | 1.33 | 1.40 | 1.44 | 1.39 | 4.63 | <0.001 | 0.472 |

[1] Productive efficiency = milk yield (kg/day)/dry matter intake (kg/day).

same occurring with doses above 35 mg/kg DM, as in the present study (48 mg/kg DM).

According to literature, milk composition varied according to the dose of supplemented monensin, to the lactation phase of the cows, to the production level, to the mode of monensin supplementation, and to the type of basal diet (especially roughage). Sauer et al. (1998), and Benchaar et al. (2006) reported reduction in milk fat content, and no change in protein content, when supplementing lactating cows with monensin. However, Ramanzin et al. (1997) observed that addition of monensin did not cause any effect on milk fat and protein contents. Milk fat and protein contents decreased when monensin was supplemented in lactating cows in the studies by Phipps et al. (2000); Ruiz et al. (2001), and Broderick (2004). In the studies which monensin reduced milk fat and protein contents, there was a parallel expressive increase in milk yield, suggesting that the dilution effect was partly responsible for the changes in milk composition (Phipps et al., 2000).

There was no effect caused by the experimental diets on the milk somatic cell count, on the body weight, on the body weight changes, on the body condition score, and on the change of body condition score (P>0.05). These results are different from the ones obtained by Duffield et al. (2008), in which the supplementation with sodium monensin increased in 0.03 points the body condition score, and in 0.06 kg/day the body weight of lactating cows. Differences of the phase of lactation, and milk yield level in the evaluated animals among the present study and the ones cited by Duffield et al. (2008) might explain these results.

Addition at different levels of sodium monensin to the diets did not affect (P>0.05) contents of crude protein, non-protein nitrogen, non-casein nitrogen, true protein, casein, casein/true protein ratio, whey protein, and all the fractions expressed as percentage of crude protein (Table 5). Even with the increase in milk yield when the animals received the M24 diet, or with the decrease in yield of the animals receiving the M48 diet, the proportion of milk fractions, expressed as percentage of milk (%), or as percentage of milk crude protein (%CP), were not altered.

Concentrations of milk protein fractions were similar among the groups, therefore it did not influence the protein metabolism in the mammary gland, fact that is justified by the stability of milk protein fractions, despite of the capacity of monensin in influencing rumen and plasma protein metabolisms.

Aquino et al. (2008), measuring milk protein fractions in mid-lactation cows, reported average values of 0.26% for milk non-protein nitrogen, 3.04% for true protein, 2.55% for casein, and 0.46% for serum protein. These results are similar to the present study. The results for casein content found in this study are similar to the levels reported by Bateman et al. (1999). Concentrations of milk true protein, and casein, as expressed in %CP, are in accordance to the values reported by Coulon et al. (1998) and Freitas Jr. et al (2010).

Despite of their clear importance, studies reporting the composition of milk protein fraction in cows supplemented with monensin are scarce. So, this important aspect related to the quality of milk should be studied with more criteria, especially by its capacity to influence the productive performance of dairy cows.

Table 5 - Milk protein fractions of dairy cows fed diets supplemented with monensin

| | Experimental diet | | | Means | CV (%) | Probability | |
|---|---|---|---|---|---|---|---|
| | Control, without monensin | Monensin 24 mg/kg of diet | Monensin 48 mg/kg of diet | | | Linear | Deviation |
| Crude protein (%) | 2.95 | 2.93 | 2.88 | 2.92 | 4.04 | 0.134 | 0.737 |
| Non-protein nitrogen (%) | 0.23 | 0.22 | 0.24 | 0.23 | 13.90 | 0.455 | 0.352 |
| Non-casein nitrogen (%) | 0.77 | 0.76 | 0.76 | 0.76 | 7.96 | 0.574 | 0.774 |
| True protein (%) | 2.72 | 2.70 | 2.63 | 2.69 | 4.71 | 0.109 | 0.582 |
| Casein (%) | 2.18 | 2.17 | 2.12 | 2.16 | 5.45 | 0.208 | 0.615 |
| Whey protein (%) | 0.54 | 0.53 | 0.52 | 0.53 | 9.93 | 0.275 | 0.805 |
| Non-protein nitrogen (%CP) | 7.84 | 7.75 | 8.43 | 8.01 | 14.38 | 0.225 | 0.351 |
| Non-casein nitrogen (%CP) | 26.15 | 25.91 | 26.49 | 26.19 | 7.90 | 0.694 | 0.585 |
| True protein (%CP) | 92.15 | 92.25 | 91.56 | 91.99 | 1.25 | 0.225 | 0.351 |
| Casein (%CP) | 73.84 | 74.08 | 73.50 | 73.81 | 2.80 | 0.694 | 0.585 |
| Whey protein (%CP) | 0.18 | 0.18 | 0.18 | 0.18 | 10.13 | 0.742 | 0.950 |
| Casein/true protein (%CP) | 0.80 | 0.80 | 0.80 | 0.80 | 2.49 | 0.762 | 0.953 |

## Conclusions

The utilization of sodium monensin in diets at the concentration of 24 mg/kg of DM improves the productive performance of mid-lactation dairy cows with average daily yield of 23.7 kg of milk and using corn silage as the roughage. The utilization of sodium monensin does not influence milk protein fraction composition.

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