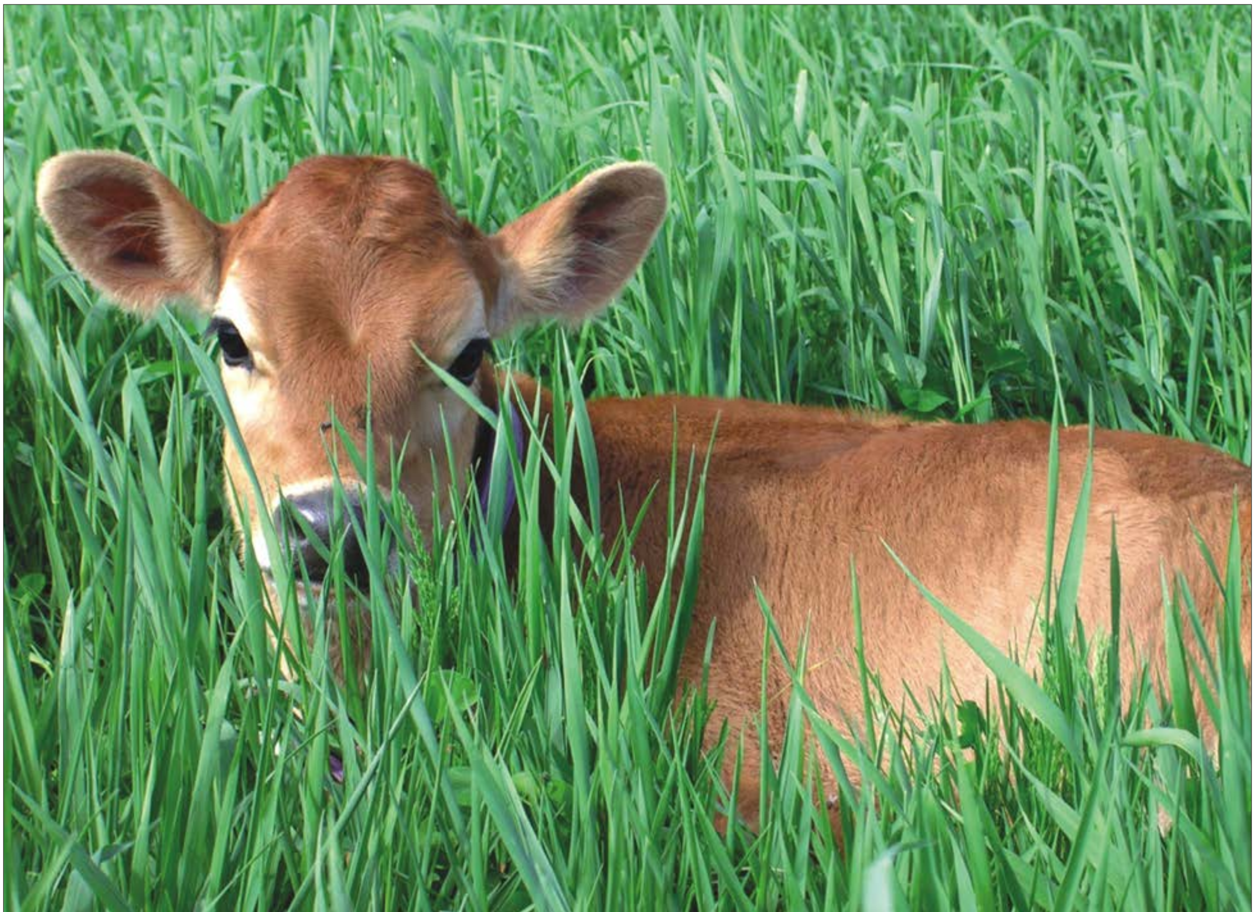

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Effects of Calcium Salts of Palm Fatty Acids and Protected Methionine Supplementation on Milk Production and Composition and Reproductive Performances of Early Lactation Dairy Cows

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Abstract: Fifty-four high producing Holstein cows in early lactation were used in a complete randomized block design to determine the effects of calcium salts of palm fatty acids and protected methionine supplementation on Dry Matter Intake (DMI), milk yield and composition and on selected reproductive parameters starting week 2 post partum through week 17 of lactation. Cows were blocked by body weight, milk production and lactation number and randomly allocated from blocks to 3 treatments. Treatments were: (1) concentrate only (Control, C) (2) control+added calcium salt (700 g/cow/day, CSFA) and (3) control+added calcium salt+protected methionine (700 g of calcium salt per cow per day containing 6% (40 g) of protected methionine, CSFAM). Cows were fed for *ad libitum* intake a basal diet consisting of tritical silage, rye-grass and oat hay. DMI and milk production were measured. Milk composition was determined and 4% Fat Corrected Milk (FCM) was calculated. Body condition scores were monitored every three weeks. Reproduction data were recorded and major reproductive parameters were computed. Results showed that calcium salt supplementation decreased DMI and milk protein content, but increased milk yield, FCM, milk fat content and yields of milk fat and protein. DMI decreased ($p<0.05$) by 1 to 1.5 kg/cow. FCM was 34.2 kg day^{-1} for the control and increased an average of 3 to 4 kg day^{-1}, respectively with fat and fat plus protected methionine supplementation. Feed efficiency was higher for cows fed the calcium salt and methionine added calcium salt diets (1.84 and 1.77 versus 1.56 kg milk kg^{-1} DM for the CSFAM, CSFA and C treatments, respectively). Percentages of milk fat were significantly higher ($p<0.05$) for cows fed fat added diets (36.3 and 36.1 versus 35.1 g kg^{-1} for the CSFA, CSFAM and C treatments, respectively). However, the protein content of milk was lower ($p<0.05$) for the calcium salt supplemented cows (30.4 versus 31.2 g kg^{-1}), but the addition of protected methionine to calcium salt did prevent the decrease in milk protein that was induced by supplemental fat alone. Yields of milk fat and protein were lower for the control cows. Body condition scores were higher for cows fed diets supplemented with fat and fat plus methionine (2.81 and 2.73 vs. 2.48 for the CSFAM, CSFA and C treatments, respectively). Supplemental fat significantly increased ($p<0.05$) the first service and overall 150 day conception rates and reduced the number of services per conception. The addition of methionine to calcium salts further improved these indices. Overall results suggest that the use of 700 g of calcium salts of palm fatty acids/cow/day in the concentrate supplement improves major reproductive indices and milk yield of high producing dairy cows during early lactation and that adding ruminally protected methionine to calcium salt not only helps alleviate the milk protein depression commonly observed with added fat, but further improves the performances of cows.

Key words: Cow, early lactation, protected fat, production, reproduction

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INTRODUCTION

Dairy cows in early lactation require tremendous amount of energy to achieve high milk yield. However, typical diets fed to cows in Tunisia are based on low quality cereal forages such as oat and tritical silages and hays. Such constraint combined with the low feed intake of cows in early lactation make a big challenge to local dairy producers in meeting animal requirements. Alternative solutions are therefore required to increase the energy density of the diet. So far, the main adopted strategy was the increase in the proportion of concentrate in the ration. However, when excess amounts of cereal grains are fed to increase the energy density of the diet, fermentation may exceed the buffering capacity of the rumen, which can lead to acidosis, health problems, decreased fiber digestion and low milk fat content. Alternatively, there has been a lot of interest in feeding fat to high yielding dairy cows in many parts of the world to increase the energy density of dairy rations. Research has demonstrated that adding fat to dairy diets improves milk production and increases persistency of lactation (Moallem *et al*., 2000; Bojalil *et al*., 1998; Weiss and Wyatt, 2004; Kokkonen *et al*., 2004; Casper *et al*., 1990; Kim *et al*., 1991; Schingoethe and Casper, 1991). In many trials, improvements in milk production by 2 to 10% were reported in cows fed fat supplemented concentrates compared to control diets containing no fat. However, studies on the effects of fat feeding to dairy cows in Tunisia are very limited, especially its effects on milk production and on major reproductive indices. The objective of this study is to determine, under Tunisian feeding conditions, the effects of calcium salts of palm fatty acids with and without protected methionine supplementation on Dry Matter Intake (DMI), milk production and composition and on major reproductive parameters in dairy cow during early lactation.

MATERIALS AND METHODS

Experimental Design and Dietary Treatments

Fifty four high producing Holstein cows in early lactation were used in a complete randomized bloc design to determine the effects of calcium salts of palm fatty acids and protected methionine supplementation on Dry Matter Intake (DMI), milk yield and composition and on selected reproductive parameters starting week 2 post partum through week 17 of lactation. The study was conducted on a commercial large dairy herd farm in Northern Tunisa during late spring early summer of 2005. Animals used for the experiment were kept separately from the remaining herd. Cows were blocked by body weight, milk production and lactation number and randomly allocated from blocks to 3 treatments. Treatments were: (1) concentrate only (Control, C) (2) control+added calcium salt (700 g/cow/day, CSFA) and (3) control+added calcium salt+protected methionine (700 g of calcium salt per cow day containing 6% (40 g) of protected methionine, CSFAM). Cows were fed for *ad libitum* intake a basal diet consisting of tritical silage, rye-grass and oat hay. Ingredients and nutrient composition of the feed are shown in Table 1. DMI and milk production were measured. Milk composition was determined and 4% Fat Corrected Milk (FCM) was calculated. Body condition score and body weight were monitored every three weeks using a scale from 1 (thin) to 5 (fat) according to (Sniffen and Fergusson, 1993). Reproduction data were recorded and major reproductive parameters were computed.

The calcium salt of palm fatty acids used in this study is commonly marked under the name Magnapc produced by the Norel Company in Egypt (Norel, Misr). It contains, on a dry matter basis, 87% fat and 12.5% ash of which 9.5% calcium. While the calcium salt plus protected methionine is 80 fat, 13.5 of ash of which 9.3 calcium and 6.5% protected methionine. Their relative contents of net energy of lactation is 5.57 and 5.4 Mcal kg^{-1} of dry matter, respectively. That is the equivalent of about 3.3 feed units for lactation (UFL) kg^{-1} DM.

Table 1: Ingredient, chemical composition and nutritive values of feeds

Parameters	Tritical silage	Rye grass	Oat hay	Concentrate
Composition (%)				
Barley	-	-	-	26.00
Corn	-	-	-	24.00
Wheat bran	-	-	-	33.00
Soybean meal	-	-	-	9.00
Mineral-vitamin mix	-	-	-	3.00
Chemical composition				
DM	38.70	13.90	92.50	87.20
Crude protein (DM%)	6.40	10.42	5.20	17.90
Crude fiber (DM%)	32.80	20.80	41.50	6.70
Ash (DM%)	8.70	5.80	8.20	8.30
Ca (DM%)	0.90	1.12	-	0.91
P (DM%)	0.32	0.42	-	0.65
Nutritive values (kg/DM)				
UFL[1]	0.55	0.58	0.47	0.96
PDIE (g)[2]	65.40	81.00	46.30	135.00
PDIN (g)[3]	46.50	97.00	29.80	120.00

[1]UFL: feed unit for lactation: [2]PDIE, true protein truely digested in the small intestine when degraded nitrogen in the rumen is not limiting: [3]PDIN: true protein truely digested in the small intestine when energy in the rumen is not limiting

Measurements and Chemical Analysis

Refusals were weighed and recorded daily before the morning feeding. They were periodically sampled and dried at 110°C to determine average DM. For each group of cows, DMI was calculated from feed offered, refusals and the appropriate DM percentages. Feed samples were collected weekly throughout the study. They were analyzed for DM, Crude Proteins (CP), Crude Fiber (CF) and minerals or ash contents according to AOAC (1990).

Cows were milked twice daily and milk yield of individual cows was recorded once a week using true tests. Milk was sampled weekly from consecutive milkings, preserved with potassium dichromate and composited as a percentage of the amount of milk produced at each milking. Composite milk samples were analyzed for contents of crude protein and fat using a Foss 4000 Milko Scan (Foss electronic, France) at the central milk testing laboratory and for total solids by drying at 110°C for 24 h.

Feed efficiency, expressed in terms of kg of milk per kg of consumed feed, is calculated as the ratio between milk production and total dry matter intake.

Statistical Analysis

All data were subject to least square analysis of variance for a complete randomized bloc design by the general linear models of SAS (1988). Differences were considered to be significant at $p<0.05$.

RESULTS AND DISCUSSION

DMI, Milk Yield and Milk Composition

Calcium salt supplementation at 3% of total dry matter intake did significantly ($p<0.05$) affect both DMI and milk production. Cows fed calcium salts had decreased DMI, but increased milk yield, FCM and milk fat content. DMI decreased by 1 to 1.5 kg/cow. Such a decrease was observed for forage dry matter intake (Table 2).

Such finding is in agreement with previous results reported by Mansbridge *et al*. (1998), who observed a decreased DMI when oil was added to dairy rations and by Son *et al*. (1996) and Schneider *et al*. (1988) using, respectively tallow and calcium salts of fatty acids. However, Sklan *et al*. (1991), Salfer *et al*. (1995), Markus *et al*. (1996) and Rebecca *et al*. (1997) have showed no difference in DMI when fat was fed as a part of the concentrate mixtures.

Table 2: Dietary effects on average dry matter intake, milk production and composition and on yields of milk fat and protein

Parameters	Control	CSFA	CSFAM
Total DMI (kg day^{-1})	23.600[a]	22.600[b]	22.100[b]
Forage DMI (kg day^{-1})	9.600[a]	8.500[b]	8.500[b]
Milk yield (kg day^{-1})	36.900[b]	40.100[a]	40.900[a]
4% FCM (kg day^{-1})	34.200[b]	37.800[a]	38.500[a]
Fat (g kg^{-1})	35.100[b]	36.300[a]	36.100[a]
Fat (kg day^{-1})	1.295[b]	1.452[a]	1.473[a]
Crude protein (g kg^{-1})	31.200[a]	30.400[b]	31.500[a]
Crude protein (kg day^{-1})	1.151[b]	1.216[a]	1.285[a]
Feed efficiency (kg milk kg^{-1} DM)	1.560[b]	1.770[a]	1.840[a]

[a,b,c]Means in the same row with different superscripts differ, $p<0.05$

Fat Corrected Milk (FCM) was 34.2 kg day^{-1} for the control and increased an average of 3 to 4 kg cow day^{-1}, respectively with fat and fat plus methionine supplementation. Clapperton and Steele (1983) reported a 5 to 10% increase in milk production when cows received additional fat in their diet. However, Schingoethe and Casper (1991) and Doherty and Mayne (1996) indicated lower increases in both milk production and FCM. In the present study the use of supplemental calcium salts, alone or added with protected methionine resulted in about 10% increases in milk production, compared to the control treatment. Similar increases were reported by Schneider *et al*. (1988). Feed efficiency was higher for cows fed the calcium salt and methionine added salt diets (1.84 and 1.77 vs. 1.56 kg milk kg^{-1} DM for the CSFAM, CSFA and C treatments, respectively).

Increased energy density of the diet reduced body weight loss during early lactation as depicted by the values of body condition scores. Indeed, body condition scores were higher for cows fed diets supplemented with fat and fat plus methionine (Table 2). Schneider *et al*. (1988) and Sklan *et al*. (1989) reported increased weight gains in cows supplemented with calcium soaps in early lactation.

Percentages of milk fat were significantly higher ($p<0.05$) for cows fed the fat added diets (36.3 and 36.1 vs. 35.1 g kg^{-1}). Similar results were reported by Kokkonen *et al*. (2004). However, Schingoethe and Casper (1991), Doherty and Mayne (1996) and Keady and Mayne (1998) reported a decrease in the milk fat content when using non protected oil fats. Such a decrease in milk fat may have been due to a lower C_2/C_3 ratio in the rumen as a result of a lower fiber digestion due to an altered fermentation pattern (Schingoethe and Casper, 1991; Doreau and Ferlay, 1995). Reduction in milk fat percentage does not always occur whenever cows are fed added fat. Indeed, Clapperton and Steele (1983) reported increased milk fat percentage when tallow was added to the concentrate mix. Similar results were reported by Kokkonen *et al*. (2004) when cows were fat supplemented during week 1 to 4 of lactation.

Percentage of crude protein in milk was lower ($p<0.05$) for the calcium salt supplemented cows (30.4 vs. 31.2 g kg^{-1}), but the addition of protected methionine to salts did prevent the decrease in milk protein that was induced by supplemental fat (30.4, 31.2 and 31.5 g kg^{-1} for CSFA, C and CSFAM, respectively). This is in agreement with major published results which indicate that increasing fat content of diets has generally decreased milk protein concentrations (Wu and Huber, 1994; Elliott *et al*., 1995), but contradictory with the findings of Keady and Mayne (1998). However, it should be indicated that for most of these trials, fat content in supplemented diets ranged from 5 to 8% of total dietary dry matter, such levels were higher than the 3% protected fat content used in the present study. Wu and Huber (1994) proposed that the decrease in milk protein concentration during fat supplementation could be attributed to an inadequacy of critical AA available to the mammary gland for milk protein synthesis as milk yield increases during fat supplementation probably as a result of a decreased feed intake. Increased milk yield during fat supplementation will increase the requirement for AA just to maintain constant milk protein concentrations. Additional fat in the diet

Table 3: Dietary effects on body condition scores, first service conception and pregnancy rates and services per conception

Parameters	Control	CSFA	CSFAM
Body condition scores	2.48[b]	2.73[a]	2.81[a]
First service conception rate	14.30[c]	45.50[b]	58.00[a]
Gestation rate by 150 days	43.00[c]	61.00[b]	75.00[a]
Services per conception	2.86[a]	2.36[b]	2.50[b]

[a,b,c]Means in the same row with different superscripts differ, $p<0.05$

resulted in a significantly higher ($p<0.05$) milk crude protein yield which confirms most previously published results. This high protein yield for the experimental cows resulted from the greater milk yield of these cows compared to those fed the non-fat added concentrate.

Reproductive Performances

Fat supplementation has significantly improved reproductive performances of dairy cows (Staples *et al*., 1998). In the present study significant improvements were observed for conception and gestation rates and for the number of services per conception (Table 3). Similar results were reported by Ferguson *et al*. (1990) and Sklan *et al*. (1991). In this study, first service conception rate increased from 14 to 45% as a result of calcium salt supplementation. Added protected methionone to calcium salts further improved first service conception rate to be as high as 58%.

Similarly, gestation rate was significantly improved by fat and fat plus methionine supplementation. It went from 43% for cows receiving the control treatment to 61 and 75% for those receiving the CSFA and CSFAM treatments, respectively. Moreover, the number of services per conception was reduced from 2.86 to 2.36 when cows were supplemented the protected fat.

Mechanisms involved in such improvement are not well understood. However, several hypotheses were suggested by Staples *et al*. (1998). The first is that feeding fats in early lactation reduces the negative energy balance of the cows allowing them to resume estrus earlier after parturition and therefore have better reproductive performances. The second hypothesis is that cows fed fat have increased progesterone production the so called hormone of pregnancy. Increased concentrations of plasma progesterone have been associated with improved conception rates of lactating cows (Staples *et al*., 1998). The last hypothesis is that specific fatty acids found in fats inhibit the synthesis of prostaglandin $F_{2\alpha}$, which prevents the regression of the corpus luteum and thus improves embryos survival. In our case, observed improvements in reproductive performances were obtained in conjunction with improvements in milk production. It is therefore plausible to suppose an improvement in the energetic status of the fat supplemented cows which allowed them to early resume reproductive function after calving and to have an improved synthesis of steroid hormones favorable for a better fertility. Such improvement is more likely the result of a better supply of essential fatty acids involved in the reproductive function coming from the supplemental fat (Staples *et al*., 1998). Indeed, usually energy deficient cows have poor reproductive performances and fat supplemented increases blood progesterone and gestation percentage (Sklan *et al*., 1991).

CONCLUSION

Results in this study suggest that the use of 700 g of calcium salts of palm fatty acids /cow/day in the concentrate supplement (about 3% of the total diet dry matter) improves major reproductive indices and milk yield of high producing dairy cows during early lactation and that adding ruminally protected methionine to calcium salt not only helps alleviate the milk protein depression commonly observed with added fat, but further improves the performances of cows. Such management strategy is a valuable nutritional alternative for dairy producers in Tunisia who are in a continuous search for improved reproductive performances of their herds and an increased profitability of their dairy enterprises, particularly under common feeding conditions characterized by low quality forages.

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