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Effect of diets with different content of starch and protein fed to dairy cows in early lactation on milk yield and traits

Fiorenzo Piccioli Cappelli, Maria Grazia Maianti, Silvia Ferrandi, Luigi Calamari, Paolo Bani

Istituto di Zootecnica, Università Cattolica del Sacro Cuore, Piacenza, Italy

Corresponding author: Fiorenzo Piccioli Cappelli. Istituto di Zootecnica, Facoltà di Agraria, Università Cattolica del Sacro Cuore. Via Emilia Parmense, 84, 29100 Piacenza, Italy – Tel. +39 0523 599203 – Fax: +39 0523 599276 – Email: fiorenzo.piccioli@unicatt.it

ABSTRACT - With the aim to study the effect on milk yield and its traits of 2 different levels of fermentable carbohydrates (LS: 25.5%, and HS: 29.5% DM) combined with 2 protein levels (LP: 15.5% and HP: 16.5% DM), 4 Italian Friesian dairy cows in early lactation housed in a tied stall were used. The experimental diets were obtained adjusting in 4 supplements the proportion of high energy fibrous (beet pulp, soybean hull) or starchy (corn meal) feeds and of meal protein more (soybean meal) or less (Soy-Pass®: xylose-treated soybean meal) degradable. The highest DMI was observed in HSHP which showed also a low content of NDF. Milk yield resulted over 45 kg/d throughout the study and higher when HSHP diet was fed (46.1 kg). Milk fat was always at high level and the lowest value (3.89%) with HSHP and the highest (4.08%) with LSLP were observed. The diets did not modified milk protein (their average levels resulted of 3.25%) and lactose content. Milk acidity and renneting traits were higher when HSLP was fed, and resulted at adequate levels when all the diets were fed. When the diets for dairy cow are formulated to cover the animal requirements and respect their digestion physiology, it is possible to reach high milk yield level and maintaining, at the same time, a high milk quality.

Key words: Dairy cow, Milk composition, Dietary starch, Dietary protein.

Introduction - The wide variations of milk price and feeds cost have made more complex to formulate diets for dairy cow, forcing the dairy farmers to find economically sustainable diets. At the same time they must fit the cow requirements and guarantee the milk quality, particularly in the Italian situation where large part of the milk is used to make cheese. The effects of diet are very complex, including the modulation of rumen microflora output, with the consequent modification of absorbed nutrient and of the endocrine system that, in turn, influences the nutrients partitioning (Hart, 1983). Adequate rate and extent of ruminal digestion of carbohydrates and protein (RDP) has been shown to maximize protein yield by rumen micro flora (Clark et al., 1992) and to reduce the body utilization of amino acids for energy purpose (Seal and Reynolds, 1993). In this situation yield of milk and its components are optimised, because the availability of nutrients for mammary syntheses is favoured (Petitclerc et al., 2000), particularly for protein, which is stimulated by higher levels of insulin, too (McGuire et al., 1995). Nevertheless, overfeeding of fermentable energy could result in milk fat content reduction and other metabolic problems, while, on the other hand, Santos et al. (1998) in their review have observed that an additional intake of rumen undegradable protein (RUP) has determined an increase in milk yield and its protein content in the 17% of the 127 studies considered. Aim of our study was to check milk yield and its traits in dairy cows fed two levels of fermentable carbohydrates combined with two levels of protein.

Material and methods - Four Italian Friesian dairy cows in the 2nd month of lactation, housed in a tied stall under controlled climate and light conditions were used. Cows were individually fed and received
the forages (corn-silage and dehydrates alfalfa and rye-grass) two times a day, every 12 hours, and the concentrate in 8 meals/d through autofeeder. Cows were allotted randomly to a 4x4 Latin square design and received approximately ad libitum 4 experimental diets for 24 days (17 d of adaptation and 7 d of controls). The experimental diets were obtained adjusting, by specific supplements, the proportion of high energy fibrous (beet pulp, soybean hull) or starchy (corn meal) feeds and of meal protein more (soybean meal) or less (Soy Pass®: xylose-treated soybean meal) degradable. The content in the supplements of salts and buffers was kept at the same levels of concentrate. The supply of protected methionine was adjusted to set it at 2.5% of the a.a. of calculated intestinal digestible protein. The supplements were fed twice a day mixed with corn silage. The dietary factors were 2 levels of starch plus sugar content (25.5% and 29.5% DM) combined with 2 levels of protein (15.5% and 16.5% DM) to obtain 4 diets: high starch and sugar and low protein (HSLP), high starch and sugar and high protein (HSHP); low starch and sugar and high protein (LSHP), low starch and sugar low protein (LSLP). Feed intake was checked daily. Cows were milked at 5 a.m. and 5 p.m., the milk was weighted at each milking and twice a week a representative sample of morning milking was collected for fat, total protein, lactose, titratable acidity, renneting traits and Somatic Cells Count (SCC) determinations. Fat, total protein and lactose were determined using Foss Electric FT120 (Foss Electric, DK). The same instrument was used for titratable acidity determination, using a calibration curve elaborated in our Institute (Calamari et al., unpublished data). Clotting ability was performed with Formawin vers. 2.0 (Foss Electric, DK). SCC were determined with Fossomatic 180 (Foss Electric, DK). The data obtained in the last 7 days of each periods were processed using the MIXED procedure of SAS.

**Results and conclusions** - The main traits of the experimental diets are presented in Table 1. Contents in starch plus sugars and crude protein resulted close to the foreseen values. The diets with high starch plus sugar content (HS) showed the lowest levels in NDF and percentage of DM from forage. As consequence the energy content of the diet resulted higher in HSLP and particularly in HSHP. RUP resulted higher in HSHP diet, due to the combination of high contents in corn meal and particularly in Soy-Pass®, both characterised by a high RUP content.

Mean values of dry matter intake (DMI), milk yield and its characteristics are reported in Table 2. DMI was at high level with all the diets with low but significant differences among the diets. The highest level was observed when HSHP and the lowest when HSLP diets were fed. DMI pattern was not related, positively or negatively, to any of the checked parameter of the diets. An average high milk yield was recorded with all the diets. Milk yield resulted higher for the two diets with the higher levels of protein (HSHP and LSHP), that were also slightly richer in RUP. This is in agreement with the results reviewed by Santos et al. (1998), where high level of RUP from treated soybean meal in the diet of cows has been observed to contribute to increase the milk yield. The highest milk yield registered for HSHP diet has been likely favoured by the highest DMI, promoted by the highest protein and lowest NDF contents. Milk fat content resulted higher when the diets with lower content of starch were fed (i.e. LSHP and LSLP), but difference resulted statistically significant only among LSLP vs. HSLP and HSHP diets. Anyway, the differences among diets were numerically limited and this can be partly due to the almost identical ether extract levels of the diets (4.5% DM), and that it was in part supplied as hydrogenated long chain fatty acids. It also suggests that rumen fermentations remained, with all the diets, with-

| Table 1. Mean traits of the diets with different starch plus sugar and crude protein contents. |
|-----------------------------------------------|----------------|----------------|----------------|----------------|
| Parameter                  | Unit / diets | HSLP | HSHP | LSHP  | LSLP  |
| UFL (Unit/kg DM)           |               | 0.93 | 0.95 | 0.91  | 0.91  |
| Starch+sugar %DM           |               | 29.26| 29.37| 25.38 | 25.39 |
| Crude Protein %DM          |               | 15.44| 16.36| 16.27 | 15.47 |
| RUP %Crude Protein         |               | 37.50| 39.43| 37.28 | 36.58 |
| NDF %DM                    |               | 32.74| 32.57| 35.55 | 35.53 |
| F/C*                       |               | 37.88| 36.57| 38.20 | 39.10 |

*percentage of DM from forages on total DM; assuming for corn silage a forage value of 60%.
in physiological ranges without relevant lowering of pH values, despite the high NSC levels of the two HS diets.

This was likely due to the frequent daily distribution of feeds, the high pef coefficients of forage NDF and the adequate diet buffering. Moreover, while for HSHP the lower fat content could be due to a dilution effect for the higher milk yield, in HSLP the lower milk yield and fat content could indicate a different nutrients partition, likely due to a higher level of insulin (Hart, 1983). Protein and lactose contents were not modified by the 4 diets. This is in contrast with our previous results, where increasing NSC of the diet resulted in a higher milk protein content (Piccioli-Cappelli et al., 1996). A suitable explanation can be that, in the present study, the levels of fermentable carbohydrates were already high even in LS diets. Moreover, if it is taken into account that mean milk protein content and milk yield were much higher (also considering the average low DIM: 85d) than in the previous study, it could be hypothesized that milk protein synthesis was already at a high level and consequently more difficult to improve. Milk titratable acidity resulted significantly higher, vs. the other 3 diets, for HSLP, and for this thesis it was also recorded the best curd firmness, but with difference statistically significant only with regards to LSHP diet. This confirm the positive relationship between milk acidity and renneting traits. Moreover, it is worthy to note that both these parameters were anyway adequate. The very low levels of SCC observed in milk of all the groups indicated a good health status of mammary gland and, consequently, that the variations observed can be mainly attributed to the dietary factors objective of the present study.

The present study has been carried out with high yielding dairy cows, which although in early lactation exhibited a high quality milk. The results obtained indicate that when the diets are well balanced for rate and extent of rumen availability of energy and protein, but also for peNDF and are correctly managed, the rumen functionality can be guaranteed also when high levels of fermentable carbohydrates and proteins are fed. Moreover, our results indicate that further investigations must be carried out to further elucidate the metabolic and endocrine factors involved in mediating yielding response to nutritional factors.

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**Table 2.** Mean values, in the last 7 days of trial, of DMI, milk yield, fat, protein and lactose contents, milk titratable acidity, curd firmness (a30) and somatic cells count (SCC).

| Parameter | Unit/diets | HSLP | HSHP | LSHP | LSLP | mse  |
|-----------|------------|------|------|------|------|------|
| DMI       | kg / d     | 25.22 a | 26.04 d | 25.57 b | 25.78 c | 0.389 |
| Milk yield | kg / d     | 45.10 a | 46.31 c | 45.68 b | 44.85 a | 3.315 |
| Fat (%)   |            | 3.91 a | 3.89 a | 4.02 ab | 4.08 b | 0.193 |
| Protein (%)|            | 3.26  | 3.27  | 3.24  | 3.25  | 0.112 |
| Lactose (%) |            | 5.08  | 5.08  | 5.06  | 5.09  | 0.068 |
| Acidity °SH/50 mL |    | 3.52 b | 3.42 a | 3.41 a | 3.45 a | 0.122 |
| a30 mm   |            | 19.25 b | 16.80 ab | 16.09 a | 16.93 b | 2.652 |
| SCC N/μL |            | 43.00 b | 27.90 a | 33.90 ab | 42.80 b | 10.98 |

a,b,c,d: P<0.05; (mse=mean square error; degrees of freedom=30).