Assessment of corn gluten feed as substitute for sunflower meal in dairy cows diets

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SUMMARY

The effect of replacing sunflower meal with dry corn gluten feed was tested on 30 multiparous dairy cows in mid-lactation, having moderate production level (21-22 l/d). The cows were randomly distributed in three groups that received corn silage, alfalfa hay, wet brewery grains and compound feed based on corn grains, wheat bran and sunflower meal (control diet). In the experimental diets, sunflower meal was replaced partially (50%) or totally by corn gluten fed. Contrary to some previous studies the dry mater intake was not influenced, which may be explained by the moderate inclusion level (14% of the dietary dry mater). Although the two feeds are different in terms of protein value, the replacement did not significantly influence the milk yield (less than 2% difference among the three groups) or the primary milk composition. This led to better protein efficiency and diminution of the nitrogen losses toward environment. Although some characteristics of the corn gluten feed (e.g. high content in slowly fermentable carbohydrates) have potential positive effects on the energy efficiency, this was not expressed into the milk production.

It is concluded that for the type of diet used in this study, sunflower meal can be totally replaced with corn gluten feed, without negative effects on the milk yield and composition of cows having moderate production level. On the contrary, the replacement led to the improvement of the protein efficiency.

Keywords: dairy cows, corn gluten, dry matter intake, milk yield, milk composition

INTRODUCTION

The by-products resulting from the wet or dry milling of corn grains are valuable feedstuffs (Schingoethe, 2009) that have the advantage of being more available for the animal feeding and more diverse in terms of nutritional traits than the originating raw material, allowing more freedom in establishing the feeding strategies. However, in order to efficiently valorise these by-products, more specific knowledge is required than in the case of corn grains.

Beside the particular problem of contamination of the raw material (e.g. with mycotoxins – Marin, 2011), another obstacle preventing their effective valorisation in animal diets is the variability of the characteristics that influence their feeding value (chemical composition, rumen degradability, etc.). For example, the crude protein content of the corn gluten feed can vary from 14 to 24%, thus obliging the users to run frequent chemical analyses (e.g. not only when changing the provider but also for each batch).

The diversity of the by-products originating from the corn grains milling might allow adapted feeding strategies than the valorisation of the unprocessed corn grains. For example, in the case of corn gluten feed, the difference between the two values describing the protein value of feeds for ruminants (intestinally digestible protein allowed by nitrogen – IDPN / intestinally digestible protein allowed by nitrogen – IDPE) is much smaller than in the case of most of the protein meals. Therefore, corn gluten feed can be a tool for reducing the overall difference of between IDPN and IDPE supplies of diets, which can increase dietary nitrogen efficiency, reduce pollution related to animal husbandry, etc., especially when the limiting factor of the diets is the energy available for microbial protein synthesis at rumen level.

On the other hand, the protein value of corn gluten feed is lower than those of the protein meals (sunflower meal, rapeseed meal, etc.), which may limit its use to animals having low and moderate production levels.

The valorisation of corn gluten feed in the diets of ruminants (including dairy cows) is not new. In time, various authors studied the possibility of using corn gluten feed for partially or totally replacing the cereals (Krehbiel 1995, Loe 1996), corn and soybean meal (Bernard 1991, Fellner and Belyea, 1991), bulk forages and soybean meal (Van Baale, 2001), distillers' grains (Loza, 2010) or more complex mixtures (Schroeder 2003). At authors' knowledge, no direct comparison with sunflower meal was made up to now.

The recent trends such as chronic shortages of protein feeds, valorisation of plants in other directions than animal feeding, volatility of feed prices, etc. may favour in certain conditions the utilisation of corn gluten feed as protein and energy source, not only for its content of digestible fibres (Farran, 2006; Dragomir 2011). The objective of this study was to evaluate the potential of corn gluten feed to replace sunflower meal, within a classical dairy cows' diet, based on corn silage and alfalfa hay.

MATERIAL AND METHODS

Animals and diets

The experimental procedures were in agreement with Council Directive 2010/63/EU for the protection of animals used for scientific purposes and with the specific national legislation. The experiment was organised on 30 multiparous dairy cows, having 105.93 ± 8.837 days in milk at the beginning of the experiment, an average milk yield of 21.17 ± 0.665 l/d, an average milk fat content of 3.79 ± 0.058% and an average milk protein content of 3.21 ± 0.051%. The animals were randomly distributed in three groups, which were statistically equal and homogenous in terms of the above mentioned parameters.

The only difference between the three groups was the diet. All groups have received corn silage, ad libitum, and fixed amounts of alfalfa hay, wet brewer's grains and specific compound feeds, whose structure is presented in Table 1.

Table 1. Structure of the compound feeds (%)

	Control group	CGF50 group	CGF100 group
Corn grains	29.8	29.8	29.8
Wheat bran	29.7	29.7	29.7
Sunflower meal	36.2	18.1	0
Corn gluten feed	0	18.1	36.2
Mineral & vitamins	4.3	4.3	4.3

Thus, control group (C) was fed a compound feed based on sunflower meal, wheat bran and corn grains, while in the experimental groups the sunflower meal was replaced in a 1:1 ratio, partially - by 50% (CGF50) or entirely (CGF100). Diets were designed to supply similar amount of energy (expressed by UFL units) and protein (expressed by the lowest values of IDPN and IDPE).

The intake of dietary ingredients was recorded daily and individually; ad libitum feeding was considered at 10% refusals.

The concentrates accounted 37% of the dietary dry mater; of this, up to 14% were constituted by sunflower meal or corn gluten feed. The dietary proportions of corn grains and wheat bran were 11% each, approximatively.

Analyses and data processing

Samples of each dietary ingredient were collected and analysed for crude protein, crude fat, crude fibre, NDF, ADF and ash content, using AOAC methods. The chemical composition of the dietary ingredients is presented in Table 2.

Table 2. Chemical composition of the dietary ingredients

	DM (g/kg)	CP (g/kg DM)	CF (g/kg DM)	Fat (g/kg DM)	Ash (g/kg DM)	NDF (g/kg DM)	ADF (g/kg DM)
Corn silage	294.9	64.5	302.4	41.1	56.1	578.2	308.5
Alfalfa hay	779.6	125.3	336.4	11.8	75.0	483.5	345.1
Wet brewer's grains	237.6	239.3	190.1	96.5	34.9	587.4	310.8
Corn grains	872.7	85.6	31.40	34.6	14.1	121.4	30.7
Wheat bran	885.2	163.2	105.9	33.1	52.1	441.3	146.0
Sunflower meal	916.1	339.6	230.5	22.8	81.3	415.4	267.3
Corn gluten feed	890.3	181.7	112.8	20.4	73.2	484.0	146.5

Milk production was recorded daily and individually; milk samples were collected three times during the experimental period, both at the morning and evening milking and analysed for protein, fat and lactose content. Milk composition was determined by infrared spectroscopy (AOAC Official Method 972.16:2006 and International IDF Standard 141C:2000), using a high capacity, automated MilkoScan 605 spectrophotometer (Foss, Denmark).

The experimental data were analysed in a monofactorial experimental design, using GLM procedure of Minitab (Minitab 16.2.4, 2013). Also, the significance of contrasts (Control group vs CFG groups, CGF50 vs CGF100) was tested.

RESULTS AND DISCUSSION

The replacement of sunflower meal with dried corn gluten feed did not influence the intake of dietary ingredients; the differences of dry mater intake being lower than 3% (Table 3). This is contrary to the results of other authors (Wickersham et al., 2004; Mullins et al., 2010; Sullivan et al., 2012), which reported the increase of DMI when feeding increasing levels of wet corn gluten feed to dairy cows. The form of corn gluten feed (wet versus dry) don’t seem to be the cause of these divergent results as Bernard et al, 1991, found no influence of the corn gluten feed form (wet or dry) on DMI. On the other hand, it has to be noted that the level of CGF inclusion in our study is rather low.

As result of the similar DMI of all experimental groups, the dietary nutritive supplies were determined mostly by the differences between sunflower meal and corn gluten feed, the later having higher energy value and lower protein content (Sauvant et al., 2002). It is important to note that the differences between the two feeds are much higher for IDPN (digestible protein allowed by the rumen available protein) than for IDPE (digestible protein allowed by the rumen available protein).

Table 3. Diets consumption and dietary nutritive supplies

	Control group	CGF50 group	CGF100 group
Corn silage (kg/day/cow)	26.79 ± 0.310	27.01 ± 0.272	26.02 ± 0.642
Alfalfa hay (kg/day/cow)	4.29 ± 0.082	4.27 ± 0.082	4.23 ± 0.089
Wet brewer's grains (kg/day/cow)	4.16 ± 0.014	3.94 ± 0.142	4.03 ± 0.044
Compound feed (kg/day/cow)	8.28 ± 0.465	8.11 ± 0.572	8.11 ± 0.266
Dietary nutritive supplies			
DMI (kg/day/cow)	19.63	19.44	19.10
UFL (/day/cow)	15.49	15.82	16.04
IDPN (g/day/cow)	1670.36	1505.13	1356.42
IDPE (g/day/cow)	1414.78	1388.96	1364.54
NDF (kg/day/cow)	6.77	6.76	6.59
ADF (kg/day/cow)	3.90	3.90	3.80

UFL = Milk Feed Units, as described by the French feeding system; IDPN / IDPE = digestible protein allowed by the rumen available protein / energy, as described by the French feeding system

As the participation of sunflower meal or corn gluten feed in dietary dry mater is consistent (≈14%), these differences were partly expressed in dietary supplies of energy: from 15.49 UFL the control group to 16.04 UFL the CGF100 group (however, less than 4%).

In the case of protein supplies, the difference in case of IDPN is very high: from 1670 g/d (control group) to 1356 g/d (CGF100 group). However, it is well known that protein value that counts is the minimum between IDPN and IDPE (Verite & Peyraud, 1988). In all three experimental diets, the minimal value was IDPE – if this value is considered, the differences between groups are minor: from 1415 g/d (control group) to 1366 g/d (CGF100 group), which means 3.6%.

Moreover, the IDPN supply of the control group is higher than nutritional requirements anyway. Actually, many farmers use protein overfeeding in order to overcome lack of knowledge or imprecisions in evaluating the nutritive value of feeds, leading to inefficient valorisation of diets. In this context, the replacement of sunflower meal with corn gluten feed could contribute to a more efficient protein valorisation into animal products and, in parallel, to lower nitrogen losses toward environment.

Although the corn gluten feed has much lower crude protein content than for sunflower meal, the consideration of IDPE as expression of the real protein value suggests that the 1:1 ratio used for the replacement ensures, at least theoretically, similar animal performances.

Indeed, the milk yields of the three groups were similar (Table 4), within 2% differences. Also, no significant differences were observed for proximal milk quality ($P>0.05$).

Table 4. Milk production and composition

	Control group	CGF50% group	CGF100% group	SEM	P	Control vs CGF	CGF50 vs CGF100
Milk yield, l/d	21.88 ± 0.954	21.81 ± 1.530	21.36 ± 1.050	1.208	0.947	0.844	0.810
Fat content, %	3.582 ± 0.044	3.738 ± 0.076	3.672 ± 0.161	0.107	0.593	0.350	0.717
Protein content, %	3.258 ± 0.101	3.255 ± 0.076	3.272 ± 0.076	0.083	0.985	0.944	0.858
Lactose content, %	4.977 ± 0.044	4.927 ± 0.054	4.897 ± 0.054	0.050	0.523	0.291	0.667

The lack of effects on milk yield and composition was also reported by other authors: Bernard et al, 1991 (at a dietary inclusion level of 27%), Fellner & Belyea, 1991 (at a dietary inclusion level of 40%), Schroeder, 2003 (at a dietary inclusion up to 30% or even 45%, when diets are adjusted for both energy and fibre supplies). There are even reports of positive influence on fat-corrected milk yield (Wickersham et al., 2004; Kononoff et al., 2006; Mullins et al, 2010), but this was mostly a consequence of increased dry mater intake upon inclusion of wet gluten feed in the diets, whereas in our study we used dry gluten feed.

In our study, the participation of corn gluten feed in diets was lower (14% only), as the objective was not to maximize its use but to obtain a better protein efficiency on a classical diet designed for cows having moderate production level.

Obtaining the same yields and composition of milk with lower supply of dietary crude protein and, more precisely, IDPN certainly shows better protein efficiency, also observed by other authors, on other categories of ruminants and other types of diets (Bowman & Paterson, 1988; Kononoff et al, 2006; Sullivan et al., 2012).

Whereas the protein efficiency increased by replacing sunflower meal with corn gluten feed, the energy efficiency remains lower than expected (21-22 l milk / d corresponding to energy supply of 15.5-16 UFL). This might be caused by an overestimation of the nutritive value of the wet brewer's grains, which is known for its storage and transport management problems.

The nature of the two feeds (e.g. the fibre of corn gluten feed is expected to be more digestible than the fibre of sunflower meal) suggests some potential positive effects on the rumen energy metabolism (e.g. a positive effect on rumen pH, as reported by Montgomery, 2004). However, these were not reflected in the milk yield and energy efficiency, as observed by other authors (Wickersham et al., 2004; Mullins et al, 2010).

CONCLUSIONS

The partial or total replacement of sunflower meal with corn gluten feed, up to 14% of the dietary dry mater, did not influence the daily dry mater intake (less than 3% differences).

The replacement allowed the decrease between IDPN and IDPE values, thus contributing to the increase of the nitrogen efficiency.

Also, the replacement did not significantly influence the milk yield or the milk primary composition (protein, fat, lactose). Upon its price on the market, corn gluten feed can successfully replace sunflower meal, despite its lower crude protein content, provided the dietary IDPE supply covers the protein requirements.

ACKNOWLEDGEMENTS

This work was co-financed from the European Social Fund through the Sectorial Operational Programme Human Resources Development 2007-2013, project number POSDRU/89/1.5/S/63258

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