Partial substitution of concentrates by maize silage in rations for organic dairy cows and its influence on performance and utilization efficiency

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Abstract – The aim of the present study was to investigate the influence of partial substitution of purchased concentrates with maize silage on feed intake, energy and nutrient supply, milk production and feed utilization efficiency in organic dairy cows.
In the experiment, two winter rations were compared. In the experimental group (E) 2/3 of average herd concentrate intake were replaced by maize silage. In group E total dry matter, protein und energy intake was significantly lower than in the control group (C) (16.3 and 17.8 kg, 99 and 110 MJ NEL, 2170 and 2460 g crude protein, respectively). Milk yield decreased in group E by 1.7 kg, which was not statistically significant. Ruminal nitrogen balance and dietary protein to energy ratio was significantly lower in group E as compared to group C (-8 and 22 g, 21 and 24 g/MJ NEL, respectively). The diet for group E had no effect on milk composition, except milk urea content, which was in tendency lower in group E (15 and 17 mg $100ml^{-1}$). Estimated milk yield from forage was considerably higher in group E (15.9 vs 13.5 kg). Efficiency of nitrogen (N) utilization was tendencially higher in group E. [1]

Introduction

On organic dairy farms, purchased concentrates are one of the main sources of external inputs. This must be viewed critically in many respects: availability and costs of organically produced concentrates, maximum forage utilization, intact nutrient cycles and farm gate nutrient balances. Therefore, maximum milk yield from forage and restricted concentrate use appear to be important goals in organic farming (Nicholas et al., 2004).
Maximal milk yield from forage requires an optimal microbial protein synthesis and therefore a synchronised ruminal energy and protein supply. Ruminal protein degradation occurs more rapidly in grass silages than carbohydrate degradation (Sniffen et al., 1992). Tamminga (1996) and Castillo et al. (2000) suggested that imbalances can be decreased by supplementing with low protein roughages such as maize silage, which is high in rapidly degradable carbohydrates and low in protein.
The aim of the present study was to investigate the influence of partial substitution of purchased concentrates with home grown maize silage on feed intake, energy and nutrient supply, milk performance and feed efficiency.

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Materials and Methods

The experiment was conducted on an organic farm in the province of Salzburg/Austria during the winter feeding period with 20 Holstein Friesian dairy cows, housed in a cubicle housing system with Calan gates for individual feeding.
In the experiment two rations were compared. Therefore, the cows averaging 140 ± 82 days in milk were divided into two groups, a control (C) and an experimental (E) group. Cows were fed grass-clover silage ad libitum in the morgning and evening and hay at noon. Concentrates were fed individually to each cow according to milk yield via an automatic feeding station. In group E, 2/3 of average concentrate intake per cow were replaced by 2.6 kg maize silage dry matter and fed in two equal portions before offering grass-clover silage. The experiment lasted for 12 weeks.
Individual forage intake was recorded during three five-day recording periods. Concentrate intake was recorded daily during the experiment. Cows were weighed once during each recording period. Milk yields were recorded automatically at each milking. Representative samples of milk, feeds and feed refusals were collected and analysed. Data were analysed using the MIXED procedure of the SAS program.

Results and Discussion

Least square means, residual standard deviation (s) and probabilities (P) concerning feed and nutrient intake, milk yield and utilization efficiencies are shown in Table 1.
Content of net energy lactation (NEL) per kilogram (kg) dry matter was 6.1 MJ for both diets, crude protein (CP) content was 130 g for diet E and 145 g for diet C, resulting in a significantly lower dietary CP to NEL ratio and ruminal nitrogen balance (RNB) in group E.
Although there was a tendency towards increased forage intake in group E, total feed intake was significantly reduced by 8 % compared to group C, indicating that maize silage was not consumed additionally, but replaced part of grass-colver silage

Table 1. Effects of a partial substitution of concentrates by maize silage on selected feed intake, performance and efficiency traits

Item	Group		s	P
	C	E		
Total DMI (kg day^{-1})	17.8	16.3	1.65	0.040
Forage DMI (kg day^{-1})	14.0	14.9	1.54	0.072
Concentrate DMI (kg day^{-1})	3.9	1.7	0.43	0.001
uCP[a] intake (g day^{-1})	2459	2171	200.1	0.013
NEL intake (MJ day^{-1})	110	99	9.1	0.040
NDF intake (g day^{-1})	8036	7484	752.4	0.076
Ratio of CP:NEL (g MJ^{-1})	23.7	21.4	0.23	<0.001
RNB[b] (g)	22.0	-8.4	3.14	<0.001
ECM (kg day^{-1})	20.7	19.0	1.23	0.379
Calculat. ECM from forage DMI (kg)	13.5	15.9	2.92	0.010
N milk, % of N intake	23.6	27.1	3.0	0.025
Concentrates (kg DM) kg ECM^{-1}	0.18	0.08	0.03	<0.001

[a]utilisable crude protein in the duodenum

[b]ruminal nitrogen balance

intake. In addition, intake of NEL and utilisable crude protein in the duodenum (uCP) were significantly reduced compared to group C.

In general, cows fed with diet E produced 1.7 kg less energy corrected milk (ECM), although this difference was not statistically significant (P=0.38). In group C one additional kg ECM required 1.3 kg concentrates, indicating a rather poor concentrate efficiency. Milk composition was not affected by the diets, except for milk urea content, which was tendencially lower in group E (15.2 and 17.1 mg 100 ml^{-1}, P=0.07). Average milk protein, milk fat and milk lactose contents were 32, 40 and 47 g kg^{-1}, respectively. Milk somatic cells counts were 125x10^3 ml^{-1}. Average milk protein yield was 0.62 and 0.65 kg day^{-1} and milk fat yield amounted to 0.77 and 0.85 kg day^{-1} in group E and C, respectively.

The three parameters CP to NEL ratio, RNB and milk urea content are indicators for the protein supply of ruminal microbes and the animal. According to Steinwidder and Gruber (2000) and GfE (2001) they are still within the recommendations. It has to be pointed out that protein supply was limiting especially in group E. Furthermore, the reduced feed intake in group E might be the result of both, lower concentrate intake and suboptimal ruminal protein supply (Gruber et al., 2005).

Theoretical milk production from forage was 15.9 kg in group E as compared to 13.5 kg ECM in group C(P=0.01), resulting in a significantly lower contentrate use per kg ECM in group E. Conversion of dietary N into milk N reflects the N capture in the rumen by microbes. Nitrogen efficiency (milk N, in % of N intake) was higher in group E which is in accordance with Givens and Rulquin (2004). This difference was only significant in recording period III.

CONCLUSIONS

The results indicate that protein supply might have been suboptimal in the maize silage group. Possible solutions could be the production of grass-clover silages with slightly higher protein contents or the use of home grown protein concentrates.

In conclusion, the use of maize silage in diets for organic dairy cows improved the efficiency of nutrient utilisation and can therefore partially replace purchased concentrates

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