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Replacing cereals and soybean meal with sugar beet pulp and rapeseed meal or distiller's grain in grass silage diets to dairy cows

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Introduction

Large volumes of human-edible products as cereal grains and soya beans are fed to dairy cows in intensive production systems (Eisler *et al*., 2014). Given the predicted increase in demand for livestock products and competition of land for food and feed, human inedible feeds are becoming increasingly important. Ruminants have a unique ability to produce high quality food, as milk and meat, from fibrous feed and other products not suitable for human consumption. Substituting human edibles with by-products as feed for ruminants substantially increase the net food production (human edible output minus human edible input) (Ertl *et al*., 2016).

The aim of this study was to investigate the effects on feed intake and milk production when human-edible feeds as cereal grain and soy beans was completely substituted with different blends of by-products as sugar beet pulp, rape seed meal and distillers grains in a high quality forage diet.

Materials and Methods

The feeding trial was carried out at the Swedish Livestock Research Centre, Uppsala (59°50'N; 17°48'E) and was approved by the Uppsala Ethical Committee for Animal Research (Uppsala, Sweden).

Twelve multiparous and twelve primiparous dairy cows in mid-lactation (70-125 days in milk at start), of the breeds Holstein (n=8) and Swedish Red (n=16), were housed in a loose housing system and milked in a single station automatic milking system (VMS^{TM}, DeLaval International AB, Tumba, Sweden).

The cows were used in a change-over experiment with four different concentrates as treatments and in three week periods. The first two weeks in each period were used for adaptation of the feeds and the last week was used for data collection and sampling. Milk was sampled during 24 hours in the middle of the third week in each experimental period.

The cows were randomly assigned to one of the four groups based on breed, parity and milk yield. All cows received grass silage *ad libitum*. The silage was a blend of 2/3 first cut and 1/3 second cut of a perennial grass lay of mainly timothy, perennial rye grass and tall fescue hybrid ensiled in round bales. The silage blend had a dry matter (DM) content of 43.7% and contained 132 g/kg DM of crude protein (CP) and 460 g/kg DM of neutral detergent fibre (NDF). The silage was feed individually and feed intake recorded (CRFI, BioControl Norway As, Rakkestad, Norway).

Concentrates were fed individually in concentrate dispensers (FSC400, DeLaval International AB, Tumba, Sweden) restricted to10 kg DM/day. The four different concentrates were based on: (1) cereal grains and soybean meal (CG-SBM), (2) sugar beet pulp (SBP) and rapeseed meal (RSM), (3) SBP and distiller's grain (DG), (4) SBP, RSM and DG, Table 1. All

concentrates had similar predicted content of crude protein (167 g/kg DM) and energy (11.6 MJ ME).

Table 1 Ingredient of the four different concentrates

Ingredient, % DM	CG-SBM (Control)	SBP-RSM	SBP-DG	SBP-RS-DG
Wheat	23.0	-	-	-
Barley	23.0	-	-	-
Oats	23.0	-	-	-
Soybean meal	20.2	-	-	-
Sugar beet pulp	-	53.0	50.6	50.1
Rape seed meal ExPro ®	-	30.2	-	16.8
Distiller's grain	-	-	36.0	15.0
Wheat bran	-	7.24	3.68	8.00
Limestone, ground	3.03	-	0.30	-
Ako Feed Cattle AK LN45[1]	2.10	4.22	3.68	3.98
Molasses	2.00	2.00	2.00	2.00
NaCl	1.00	-	-	-
Palm kernel expeller	0.97	3.00	3.00	4.00
Green meal pellet	0.81	-	-	-
Lipitec Bovi LM BB[2]	-	-	0.22	-
MCP Yara[3]	0.38	-	0.17	-
Magnesium oxide	0.36	0.09	0.21	-
Premix[4]	0.20	0.20	0.20	0.20

[1] Fatty acids (99% fat; 45% C16:0, 37% C18:1)
[2] Fatty acids (99% fat; 40-55% C16:0, 40-55% C18:0, max 8% C18:1)
[3] Contains 23% P, 16% Ca and 1% Mg.
[4] Containing minerals, vitamins and trace elements.

Table 2 Chemical composition of concentrates

	CG-SBM	SBP-RSM	SBP-DG	SBP-RSM-DG
DM, % of fresh matter	88.2	87.7	87.2	87.7
CP, g/kg DM	177	178	183	179
Crude fat, g/kg DM	51.2	67.8	75.5	67.4
NDF, g/kg DM	137	323	305	322
Ash, g/kg DM	71.7	54.8	58.4	53.6
Starch, g/kg DM	394	36.0	38.3	32.5
ME, MJ/kg of DM[1]	~~11.7~~ 13.3	~~11.6~~ 13.2	~~11.6~~ 13.3	~~11.6~~ 13.2

[1] Predicted, not analysed value.

Table 3 Proportion of feed components in total diet

	Diets			
	CG-SBM	SBP-RSM	SBP-DG	SBP-RSM-DG
CP, % of DM	15.0	15.0	15.2	15.0
Crude fat, % of DM	3.43	4.10	4.41	4.04
NDF, % of DM	33.1	40.5	39.8	40.6
Ash, % of DM	8.27	7.59	7.73	7.57
Starch, % of DM	15.7	1.45	1.54	1.27
Not analysed, % of DM	24.5	31.3	31.3	31.5

The data was analysed by SAS (version 9.4, SAS Institute Inc., Cary, NC, USA) PROC MIXED using a change-over model with the effects of treatment, period, order and cow as random variable.

Results and Discussion

Total dry matter intake (DMI) and silage DMI was not affected by substituting a concentrate made of cereal grains and soybean meal with concentrates entirely based on these by-products. This is in accordance with previous studies comparing CG to SBP and wheat bran (Ertl *et al*., 2016; Dann *et al.*, 2014), RSM to DG (Mutsvangwa *et al*., 2016), SBM to DG (Anderson *et al*., 2006) or SBM to RSM and DG (Maxin *et al*., 2013)**.**

Table 4 Mean treatment effects on daily intake and milk production between the four different concentrates

	Diets					P-value
	CG-SBM[1]	SBP-RSM	SBP-DG	SBP-RSM-DG	SEM	Treatment
Intake (kg/d)						
Silage, DMI	14.3	14.3	14.0	14.9	0.61	0.59
Total DMI	23.8	23.9	23.4	24.5	0.74	0.34
Yield (kg/d)						
Milk	32.0^{ab}	32.5^{a}	30.5^{b}	32.0^{ab}	1.02	0.01
ECM[2]	33.8	35.0	33.0	34.2	0.99	0.08
Composition (%)						
Fat	4.37^{a}	4.57^{ab}	4.68^{b}	4.53^{ab}	0.12	0.04
Protein	3.46	3.47	3.39	3.46	0.05	0.32
Lactose	4.84	4.75	4.81	4.75	0.04	0.10

[1] Control diet.
[2] ECM calculated according to Sjaunja *et al.* (1990).

As expected, the starch content of the by-product based concentrates was much lower. Cows fed a by-product diet consumed less than 400 g starch per day, and the NDF content was much higher compared to the control with cereal grains (Table 2 and Table 3). The by-product based concentrates had a sugar beet pulp content of 50-53% of DM (Table 1), which provides ruminants with rumen-fermentable carbohydrates other than starch, mainly from the NDF fraction of the feed (Chase, 2007). When fed the by-product diets, the cows consumed around 40% NDF of total DM and produced equally well as the ones fed the control diet (33% NDF of total DM, Table 3). Around 31% of the DM in the by-product based concentrates were not

accounted for by the chemical analyses, while this fraction was about 25% of the DM in the control concentrate (CG-SBM). Most likely a large part of the unknown compounds in the by-product based concentrates were pectin and other carbohydrates sources that are not included in the NDF fraction of the feed.

No significant differences were observed in yields of energy corrected milk (ECM) or for the content of protein and lactose in the milk just as in previous studies (Ertl *et al*., 2016; Dann *et al*., 2014; Maxin *et al*., 2013). Anderson *et al*. (2006) got similar results for protein and lactose content when feeding DG as primary protein source compared to a diet with SBM. In another study, comparing RSM to DG as protein sources in feed similar results were obtained for ECM and protein as this study, but significantly higher lactose content in the milk was reported (Mutsvangwa *et al*., 2016). The overall level of ECM yield in this study (33-35 kg/d) was somewhat higher compared to the study by Maxin *et al.* (2013) who reported 30.0-30.9 kg ECM/d even though the forage proportion was only 38% in that study and 60% in the present study. Ertl *et al.* (2016) had a production levels of only 22.5-22.7 kg ECM/d and fed their cows a 75% forage diet on a DM basis.

In the control diet, soybean meal was the main protein source in the concentrate, while in the by-product based concentrates, it was the rape seed meal and/or distiller's grain that mainly contributed to the protein content. In this experiment, higher milk production was observed when feeding SBP-RSM compared to SBP-DG. Huhtanen *et al.* (2011) and Martineau *et al*. (2013) performed meta-analyses and concluded that milk production was usually greater in cows fed a diet containing RSM compared to other protein sources as SBM. However, in the present study no difference between SBP-RSM or SBP-RSM-DG and the control (CG-SBM) was observed.

Milk production was higher among cows fed the diet with SBP and RSM (32.5 kg/d) compared with the diet containing SBP and DG (30.5 kg/d). On the other hand, Anderson *et al.* (2006) reported higher milk and ECM yields on a diet with DG compared to SBM. In other studies, no effect of different by-products was observed on in milk yield (Ertl *et al*., 2016; Dann *et al*., 2014; Maxin *et al*., 2013).

The milk fat content was higher in cows consuming the SBP-DG diet than in cows that got the control diet with CG-SBM (table 4). The present result contrasts with those of many other studies in which no effect on milk fat content was observed when replacing CG or SBM with different by products (Ertl *et al*., 2016; Mutsvangwa *et al*., 2016; Dann *et al*., 2014; Maxin *et al*., 2013; Andersson *et al*., 2006). In the present study, the more fat that was added to the concentrate, the higher content of fat was found in the milk (table 2 and table 4). Adding C16:0 fat to the feed increases milk fat content (Lock *et al*., 2013), which could contribute to the relationship between fat content in concentrate and in milk. The higher fat content in milk might also be explained by higher NDF and lower starch proportions in the by-product feeds (table 2), which is accordance to studies comparing different forage to concentrate proportions (Aguerre *et al.,* 2011; Argov-Argaman *et al*., 2014; Patel *et al*., 2012; Sterk *et al*., 2011).

Feeding high quality grass silage and by-products to dairy cows may be a way to increase the total production of human edibles without lowering the efficiency of intensive milk production systems. Future studies will evaluate the economic and environmental aspects of a dairy production system based on forage and by-products.

Conclusions

In conclusion, replacing concentrate based on cereal and soybean meal with concentrates based on human inedible agricultural by-products in a diet to dairy cows in mid-lactation did not impair feed intake or milk production when combined with a high quality grass silage.

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